The Theory and Practice

OF

INFANT FEEDING

With Notes on Development

BY

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Second Edition, Revised

WITH NUMEROUS ILLUSTRATIONS

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To my
FATHER AND MOTHER
this volume is
affectionately dedicated

PREFACE TO SECOND EDITION.

WHEN the first edition of this book was issued it was thought that artificial infant feeding could not advance much beyond its position at that time, unless the scope of study was broadened. The correct basis of the science of artificial infant feeding was then thought by many to be an adjustment of the quantitative differences of cow's milk and breast milk, and the alteration of the reaction of cow's milk to litmus paper by the addition of lime water or bicarbonate of sodium. A purely chemical basis was sought to be established.

The author has never felt that this was a correct view of the subject, and, while accepting all that was an advance, has thought that the suitability of a food for infants was not a matter of its chemical composition alone. It is gratifying to find that the most experienced investigators of the problems of animal nutrition have adopted this view with regard to the feeding of *all* species of animals, and that adaptation of the food to the particular species of animal *according to its digestive apparatus* is a recognized first principle of feeding.

Since the first edition appeared, much work has been done with modern and improved methods in the comparative chemical examination of breast milk and cow's milk, with the result that many of their supposed differences

have disappeared. The supposed distinctive difference of breast milk being alkaline and cow's milk acid in reaction, has been shown to be non-existent and due to the use of improper and unsuitable methods of determining the reaction. So this supposed fundamental difference proves to be of little significance and has lost its importance.

Very important discoveries pertaining to cow's milk have recently been made, among which are some of the changes that take place in the digestion of milk and the effect of the addition of alkalies on the digestion of milk, all of which tends to make clearer the physiology of milk and the true principles of artificial infant feeding.

The book has been carefully revised and some portions have been re-written and extended, and it is hoped that the second edition will more clearly than the first show what a peculiar and distinct position artificial infant feeding holds in the subject of dietetics.

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PREFACE.

THE great and increasing importance the subject of artificial infant feeding is assuming in all classes of society has led the author to believe there might be a field for a work on this subject that, instead of laying down rules and formulas for preparing food supposed to be suitable for infants of different ages, aimed rather to show the fundamental principles of growth, nutrition, and digestion during infancy, and then leave it to the physician to apply these principles. The discovery that the law of conservation of energy applies to animal life has made the nutrition of adults almost an exact science. In infant feeding there are other problems than mere nutrition that must be considered. The great mass of literature on infant feeding that has appeared within the past few years has been devoted in the most part toward producing a substitute food that should chemically approximate human milk. In this book the special function of milk in developing the digestive tract of the young animal is treated, the author believes, for the first time, and it is more than likely that further study along this line may necessitate greater or less modification of the conclusions here drawn.

PART II.

RAW FOOD MATERIALS.

PART III.

PRACTICAL FEEDING.

CHAPTER I.

GENERAL INTRODUCTION.

Two controlling factors are present in all life—heredity and environment. At the birth of the individual the first has done its best or worst and cannot be reckoned with in the sense of being influenced. Its activity has been through long reaches of past time, and the laws of its operation are but imperfectly understood. The question of environment, being of the present and to a certain extent possible of control, assumes the greatest importance. While from a purely biologic standpoint heredity may appear to be the most important influence, yet in the scheme of evolution the higher the animal the more important becomes environment. This is specially emphasized in man by the prolongation of the period of infancy. John Fiske was the first to elaborate this fruitful view of one of the fundamental laws of higher evolution, that not only throws a strong light on the methods of evolution, but lays the greatest importance on the period of infancy as influencing the future development and usefulness of the animal. This long period of helpless infancy is a time of extreme plasticity, when the career of the individual is no longer predetermined by the career of its ancestor. One generation of the lower animals is almost an exact reproduction of the preceding one. The young animal is born pretty fully formed, and can look out for itself almost

from the beginning, independently of the parent. The longer the infancy of an animal becomes, the greater the period of its teachability, and a slow growth means an increase in capacity for development and all the higher prerogatives. Thus the higher apes have a helpless babyhood, when for two or three months they are unable to feed themselves or move about independently of the parent. The human infant is distinguished from the highest of the lower animals by the very long duration of helpless infancy and the marked increase in the size of the brain, and particularly in the extent of its surface. There is here a great increase in the size and complexity of brain organization that takes place largely after birth. Accompanying the rapid growth of the nervous system is that of the skeleton and various visceral organs. During the first two years of life the brain not only doubles in weight, but increases marvellously in its convolutions and complexity. The infinite distance between man and the lower animals consists in the fact that in the former natural selection confines itself principally to the surface of the brain, and requires a long period of helpless infancy for this highly plastic work to be properly started and developed. Inherited tendencies are there, but the proper environment counts for much in this work so potent in future possibilities. It is evident that, correlated with his long period of helpless infancy, there must be a time of maternal care and watchfulness, if the race is to exist in health and vigor. Knowledge is required as well as care, for mistakes made at this time can never be completely corrected. The first few years of life are, biologically speaking, the most important ones we live. The begin-

ning organism has at this time stamped on it the possibilities of future vigorous life or of early degeneration and decay. Hence a careful study and understanding of all the phases of infancy are of the greatest importance alike to physicians and parents. At a period of such rapid growth and development, it is evident that proper nutrition must play the leading part. All competent observers are agreed that the best nourishment for a baby naturally comes from its own mother. Unfortunately a large number of mothers, from physical or social causes, are unable to give this proper nutriment. It appears to be one of the penalties of modern civilization that an increasing number of women cannot or will not nurse their offspring. Hence it is that in recent years a large amount of study and labor has been expended upon substitute infant feeding. Great advances have been made, but it must be confessed that the results are not always proportionate to the labor expended. The tendency appears to be to a greater degree of complexity and elaborateness than the average practitioner and mother can understand or apply. Hence discouragement is apt to follow, and a return to old and haphazard methods if the immediate results are fairly satisfactory. Proprietary infant foods also profit by this feeling of confusion, as they often agree with the baby for the time being, although not containing the proper ingredients for healthy growth and nutrition.

The effort to place the food principles of milk in their proper ratio has led to "percentage feeding," which represents a decided advance, but has been pushed to an extreme that is difficult, if not impossible, to apply. The author has long thought that some of the benefits of this

method of feeding come more from the care and cleanliness with which the milk is handled than from the minute changes in the percentages that are often advised; indeed, analysis sometimes shows that these fine changes are more on paper than in the ingredients of the milk. It is well to think in percentages and be as exact as possible in feeding a baby, but the problem has not thus been completely solved, when we are putting the milk of one species of animal into the stomach of another species having a different digestive apparatus.

The greatest problem in the life of any animal is that of securing sufficient food. All forms of animal life demand the same ultimate food elements, so that really their great diversification is along the lines of methods and organs provided by nature for securing and digesting food. While the outward forms of animals are apparent to every casual observer, their digestive systems, which are hidden, are as much diversified as their more apparent shapes, and are as much adapted for the digestion of a particular food as the outward organs are for securing it. Hence the milk of each type of animal must be studied from the standpoint of its special adaptation to the digestive tract for which it is intended: a hard curding milk is intended for a polygastric digestive tract that can properly deal with it; a soft curding milk for a monogastric digestive tract. These differences assume the greatest importance when the milk of one species of animal is fed to another species. This subject will be carefully considered in the present work, as it has a direct practical bearing upon successful infant feeding. While percentage feeding and the physical differences in the same

ingredients in the milks of different species are of great importance, the preliminary question of how to get *clean, fresh cow's milk* is the fundamental one. Too little attention has been given to this question in works on infant feeding. It will here be treated at some length and in detail, as the observations of the author lead him to believe that future advances in infant feeding must be principally along this line. In order to insist upon pure, clean milk, the physician must know how it is produced and insist upon proper conditions. It can easily be produced anywhere, if the details are properly carried out; and this does not require an elaborate, expensive plant, as many believe. It calls for knowledge on the part of the physician or sanitarian that can easily be conveyed to the farmer and dairyman. This is the first requisite in successful infant feeding.

CHAPTER II.

HOW TO APPROACH THE SUBJECT OF INFANT FEEDING.

1. Any one called on to feed an infant during the period it is normally nourished by its mother has a great responsibility thrust upon him and one not to be assumed lightly or without preparation. Too many are satisfied when something that is retained in the stomach and causes a gain in weight is found, no thought being given to whether the food contains material out of which healthy tissue can be formed.

It has often been stated that an artificial food for infants should contain nothing that is not found in mother's milk, and that it should contain *just* what is found in mother's milk. To prove the suitability of various substitutes for mother's milk chemical analyses of both have been published, to show how closely the substitutes approximate mother's milk. At first sight this seems a rational procedure, but when it is remembered that there is no difference between a diamond and a piece of charcoal *chemically*, and that mixtures of butter, cheese, sugar, salts, and water, or of beef suet, raw beef, sugar, salts, and water, can be made which when analyzed by the usual methods will show the same composition as mother's milk, the fallacy of judging the suitability of a food for an infant, or for an adult for that matter, by its chemical

analysis *only* will be apparent. *Physiological chemistry has not advanced sufficiently to make it a safe guide by itself.*

In feeding an adult it is only necessary to furnish enough food to repair waste. In feeding an infant not only must waste be repaired, but material to build up new tissue must be supplied, or the infant cannot grow normally. The whole future of the infant may depend on what kind of food is supplied it up to the time it can take table food. Then the danger of an insufficient supply of tissue-building food is not so great.

The ability to resist disease depends largely on having the cells in which the vital processes take place plentiful in number and well nourished. These cells form a large portion of all the organs and tissues of the body, and if the material needed to build *cells* is not furnished in sufficient quantity, the gain in weight, if there is any, will be mostly fat and water. It does not follow that because a baby is fat that it is strong or healthy. The *cells* may be actually starving and so few in number that the body may be likened to a large showy house built with very light timbers, all ready to collapse under a slight strain (128).

Not only must the food for an infant contain material from which cells may be built up, but the material must be in such a condition that the infant can digest it without undue effort. Furthermore the food must be cheap enough to be within the reach of all and easily prepared.

Naturally the milk of the cow or of some other animal is suggested, but experience shows that these milks do not agree with infants generally, unless in some way changed or modified, the great difficulty being the inabil-

ity of the infant to digest the elements of the milk of which cells are composed. Undoubtedly the milk of all animals contains the materials necessary to build up strong healthy cells and tissues, as no young animal thrives as well on anything else as it does on its mother's milk or on the milk of some other animal of the same species. At first thought it seems strange that the milk of one species of animal is not suitable for the young of another species; but when the mode of living, and the digestive systems, rate of growth, and stage of development at birth of the different species are compared, it will be found that *the milk of each animal is adapted to its own digestive system, rate of growth, and state of development;* also that *the milk of the mother behaves in the young animal's stomach very much as the food of the mother behaves in her stomach.* The young animal is being educated to digest in the same manner as it will when it is grown. This subject will be gone into in detail in subsequent chapters, as it has been given very little or no consideration by writers on infant dietetics.

Before there can be intelligent food prescribing there must be a knowledge of the substances needed to construct cells and keep them well nourished; of the sources from which these substances may be obtained; of how they are transmitted to the cells through the blood stream after digestion and absorption; of the nature of digestion and the digestive systems of different animals; of what changes take place in the food in the cells, and what becomes of the waste products. Then only can feeding be taken up in a scientific manner.

The problem of feeding infants in all classes of society

calls for ability to produce a satisfactory food in a simple and inexpensive manner. This necessitates a knowledge of raw food materials, how they are produced, and the best means of preserving them from deterioration and infection by disease or other kinds of germs, and how these food materials, no matter what their source, may be best prepared for digestion by the infant.

Before taking up methods of preparing food for infants, some space will be devoted to physiological chemistry, physiology of young animals, comparison of the digestive systems and milks of various animals, the production of milk and other raw food products, and methods of analyzing and testing food materials.

CHAPTER III.

ANIMAL CELL—ITS CONSTITUENTS—GROWTH A PROCESS OF CELL DIVISION—YOUNG ANIMAL RUDIMENT OF PARENT.

2. The unit of the animal organism is the *cell.* In the cells all the vital processes take place. They are the chemical laboratories of the body and are the ultimate destination of all the food that is digested. The lowest forms of animals are single-cell animals. These single-cell animals carry on all of the chemical processes that highly organized animals carry on. Every part of a single-cell animal can digest food, every part can breathe, every part can feel, and every part can think. All the faculties of an animal are bound up in one cell. The starting-point in the development of any animal is a single cell about one hundred and twenty-fifth of an inch in diameter. This cell divides and forms two cells, these divide, and so on. This increase in number of cells constitutes growth (Figs. 1 and 2). An organized animal, therefore, is a nation of cells, divided into many executive branches or organs. Certain organs are adapted for securing food, others for digesting it, and others for throwing off waste products. Then there is the circulatory system that carries the necessary food to every cell in the body. All cells are in some way in communication with the blood supply and able to select from it food particularly suited to their needs. The cells of the bones select mineral matter from the blood, other cells select other matter

that contains little earthy material. What none of the cells wants is excreted in the urine. It is absolutely beyond human power to control the food requirements of a

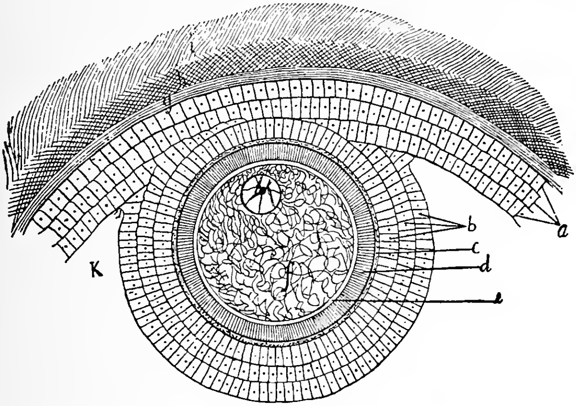


FIG. 1.—Section of Ovum. (Jewett.) Shows the original cell or starting point of an animal.

cell; if it does not want particular food substances that are in the blood it will not take them, and if the food the

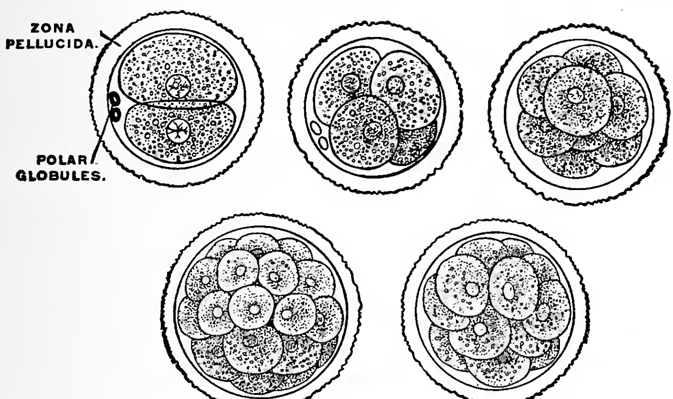


FIG. 2.—Illustration of Cell Division or Growth. (Allen Thompson, after E. Van Beneden.)

cell does want is not supplied, starvation of the cell is sure to result. Therefore a study of the cells is necessary to show their food requirements.

The cells are so small that they cannot be examined except by the aid of a microscope, but as they make up a large part of the tissues of the body, a study of the tissues is practically a study of the cells.

To the eye a piece of flesh consists of muscle, connective tissue, cartilage, fat, and possibly mucous membrane, skin, blood-vessels, and nerves.

The chief mass of these tissues, with the exception of water and fat, is called *protein substance*—the word protein meaning "*I take the first place.*" *All* protein substance contains *carbon*, *hydrogen*, *oxygen*, and *nitrogen*. *Most* of it contains in addition *sulphur*, and portions contain also *phosphorus* and *iron*. While the quantities of these elements vary somewhat, they are fairly constant in all of the tissues, but a chemical analysis of protein would not tell whether it came from skin, mucous membrane, or muscle. Other means of examining tissues had to be devised. These consist of extracting the tissues with various solvents. By this process *various forms of protein* can be separated to a certain extent. The principal groups of protein substances so separated are:

(1) Albumins and globulins, containing carbon, hydrogen, oxygen, nitrogen, and sulphur.

(2) Nucleo-albumins, containing carbon, hydrogen, nitrogen, oxygen, sulphur, and also phosphorus and iron.

There are many forms of protein that are included in these divisions; for instance:

White of egg is a mixture of albumin and globulin.

Casein of milk (curd) is a nucleo-albumin.

Another class of substances which contain *carbon*, *hydrogen*, *oxygen*, and *nitrogen*, but which are not protein

substances, can be separated from animal tissues. These are called *extractives* or *meat bases*. The extracts of meat for making beef teas, sold in jars, which are claimed to represent ten to twenty times their weight of meat, are "extractives" **(110)**.

Fat, which is composed of carbon, hydrogen, and oxygen only; lecithin, a kind of fat which contains also phosphorus and nitrogen, found particularly in the brain and nerves; and glycogen or animal starch, composed of carbon, hydrogen, and oxygen, but in proportions different from those in fat, can also be separated from animal tissues.

Mineral substances found in the tissues are thought to be combined with the protein substances and not to exist in a free state.

3. In examining cells under a microscope, it is found that a certain portion of each cell—the nucleus—contains *iron* and *phosphorus*, and that the albumins and globulins which do not contain iron and phosphorus serve more as cell food than as cell builders. Lecithin and glycogen seem to be found in all cells.

There can be no cell division or growth unless the nucleus of the cell first divides, and, as iron and phosphorus are contituents of the nuclei of cells, there can be no cell growth unless food containing iron and phosphorus is furnished. This has been proved by experiment.

The materials necessary to build up cells must be found in eggs, as in an egg there is a single cell that begins to divide and ends by changing the contents of the shell into a live bird. The germinal cell is situated near the yolk, which is used up first, and then the white is drawn on. The *yolk* is rich in *protein containing phos-*

phorus and iron, lecithin, fat, and mineral matter; while the white of the egg, which is about eighty-five per cent water, contains almost nothing that could be used to create cells (2).

4. Up to the time an animal is born it is nourished by the blood stream of its mother, so all the elements for the developing animal must come originally from the mother's food. It would be expected that animals that feed on flesh, as cats and dogs, would be able to supply the materials needed to construct animal tissue; but animals that feed exclusively on vegetable substances, as cows, sheep, and horses, also have no difficulty in constructing animal tissue. In fact, most of the meat supply of the world is the flesh of animals that live exclusively on vegetable substances, so the only conclusion is that the vegetable kingdom must be able to supply all the materials necessary to form animal tissue.

Examination of hay, wheat, oats, barley, corn, beans, etc., shows them to consist principally of carbohydrates which contain only carbon, hydrogen, and oxygen. Cellulose, or the skeleton of plants, starch, and sugar are typical carbohydrates. Paper is made of the cellulose or cells of wood or straw. Potatoes and cereals contain large quantities of starch, and beets, sugar cane, and maple trees supply sugars. Starch and sugar are the stored-up food of plants. Vegetable tissues contain also small quantities of fat and lecithin and substances containing carbon, hydrogen, oxygen, nitrogen, and also sulphur, phosphorus, and iron, called *vegetable protein*. It is these substances that are converted into animal cells. Gluten or the sticky, stringy part of bread dough is a familiar

form of vegetable protein. Chemically there is little difference between gluten and lean meat.

There is one important fact to be remembered: plants have the ability to take water, mineral matter and gases from the soil and air and combine them into proteid, fat, and carbohydrates. Animals cannot do this nor can they change fat and carbohydrates into proteid, but must take these three substances from the vegetable kingdom and elaborate them for their own particular uses; so a perfect food must contain proteid, fat, and carbohydrates in proportions suitable to the needs of each particular animal.

It is evident that a cat or dog would starve if fed hay and grass, and that a horse or cow would not as a rule thrive on raw meat. Human beings feed on meat and vegetable substances, but not in the condition in which the lower animals eat them. They must be prepared by a cooking process before the human digestive apparatus can act to advantage. This forces the conclusion that the digestive system of each kind of animal must be particularly suited to its natural food. As young animals are miniatures or rudiments of their parents, their digestive systems must be in a general way like those of their parents, so it would be natural to suppose the mother's milk would be particularly suited to the young animal's digestion, and that the milk of one kind of animal would not suit the young of another kind any more than the food of a cat would suit a cow or a horse. It is the substitution of some other milk that causes so much trouble in infant feeding. Chemistry has never been able to show why this substitution causes trouble. The answer has been hinted at,—different digestive systems. In the following chapters this important subject will be treated.

CHAPTER IV.

OBJECT AND PROCESSES OF DIGESTION—MECHANISM AND COMPARISONS OF DIGESTIVE TRACTS.

5. THE *object* of digestion is to separate from the food that is eaten those portions that will serve as nutriment to the organism from those that are useless, and to put them into soluble, absorbable forms, so that the blood can carry them to every part of the body.

The *process* of digestion consists of two distinct parts: (1) a mechanical part, and (2) a chemical part. The mechanical part consists of grasping, tearing, chewing, or grinding the food; the chemical part in the solvent action of the various digestive juices.

The *chemical changes* that take place in a particular kind of food during digestion are practically the same in all forms of animal life, but the mechanism of digestive tracts varies greatly, and the kind of digestive juices that are secreted depends largely on the natural food of the animal. *All animals must have protein in some form and all have digestive juices that will digest it*, while some animals have in addition digestive juices that will digest many other substances. A dog whose principal food is animal protein (meat) does not need a digestive juice that will soften hay or grass, and does not have it. A horse or cow needs a digestive juice that will soften and digest

the fibres of hay or grass and liberate the vegetable protein they contain, when the same chemical change in the protein takes place as in the dog's digestion.

The discussion of what are the chemical changes that take place during digestion will be deferred until the mechanism of digestion has been briefly considered.

6. To furnish a dog a pound of protein, about four pounds of lean meat would be fed, meat being about three-fourths water; to supply a horse a pound of protein, about thirty pounds of grass or sixteen pounds of dry hay would have to be fed. It is apparent that not only must the digestive system of a horse be relatively much larger than that of a dog, but much more complicated.

It is a well-established fact that the more complicated the food the more complicated is the digestive tract.

When a jelly fish comes in contact with its food it folds itself around it. When all the nutriment has been extracted it unfolds again. In a higher form of life the digestive cavity is permanent and is a straight tube. Ascending in the animal scale, the digestive tract becomes longer, curved, and separated into distinct parts that have special functions. Organs for grasping the food are provided, and the character of the food and the digestive system of the animal can often, if not always, be known by a glance at these structures.

Animals of prey have teeth adapted for tearing flesh and crushing bones. Their gullets are distensible, and they can swallow great pieces of meat and bones. Their digestive juices are particularly adapted for dissolving meat and even bone, and their digestive apparatus is short and simple. Their stomachs are capacious, being *sixty*

to *eighty per cent* of the whole digestive tract, and the outlet to the intestine is small and kept closed until the food is liquefied, thus insuring thorough gastric digestion.

Herbivorous animals, like the cow, goat, sheep, horse, and ass, have teeth for thoroughly chewing their food, and their gullets are small and non-distensible.

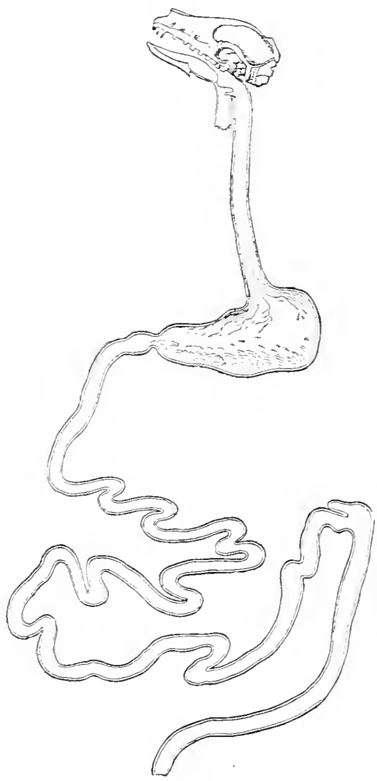


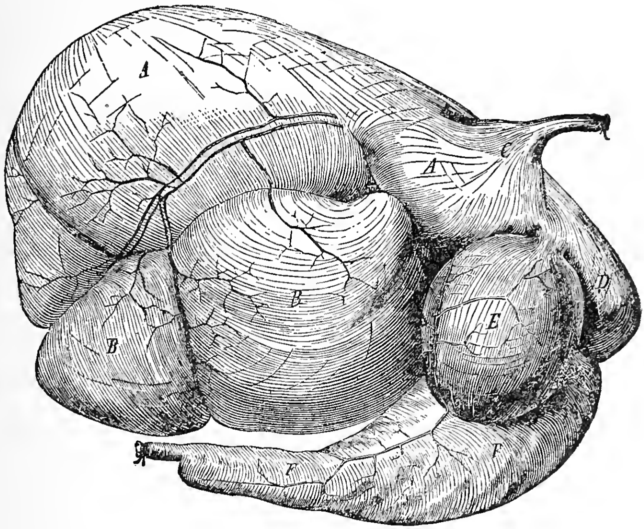
FIG. 3.—Simple Digestive Tract of Carnivorous Animal (Dog) Stomach sixty to eighty per cent (After Bernard, modified.)

With the cow, goat, and sheep, the food is first swallowed without chewing, and goes into the paunch or rumen, where it is softened very much as is the food in a bird's crop. The animal lies down and at its leisure ruminates or rechews the food, which then goes into the fourth stomach—these animals have four stomachs—where it is principally digested, and then passes into the intestines through a small outlet, which allows only liquid or semi-liquid food to pass out.

The stomach of the cow, goat, and sheep comprises about *seventy per cent* of the digestive tract.

The horse and ass, which eat the same kind of food as the cow, have entirely different digestive systems. They

chew their food once for all. Their stomachs comprise only *eight* to *nine per cent* of the digestive tract, and will



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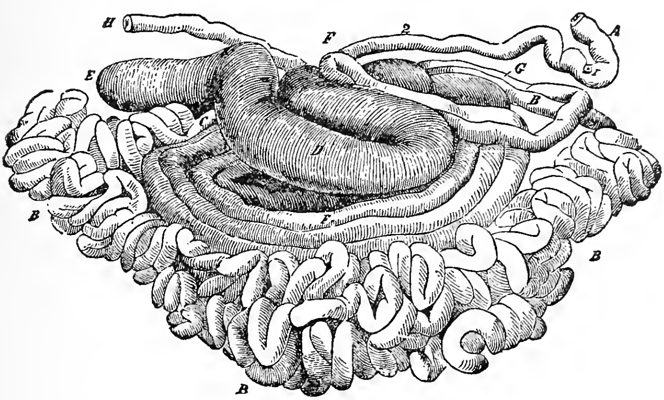


(2)

Fig. 4.—Complicated Digestive Tract of Ox or Cow. Stomach seventy per cent. (Chauveau.) (1) Stomach. (2) Intestines.

not hold more than one-third to one-half of a meal. The outlet to the intestine is large and open, and while the

animal eats a meal the food passes directly into the intestine, which at the farther end is enormously developed, forming about *sixty per cent* of the entire digestive tract.

Young birds of prey are fed flesh, young worm-eating birds are supplied with worms, and young seed-eating birds with seeds. Here it is plain that the digestive sys-

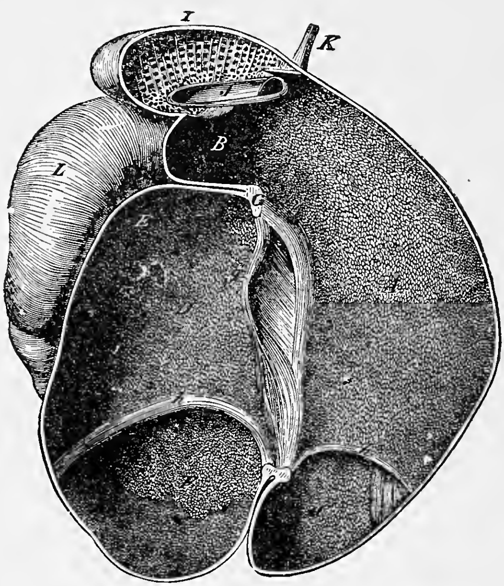


Fig. 5.—Interior of Ox's or Cow's Stomach. (Chauveau.)

tems of young birds are very much the same as those of the parents. All young animals that are suckled are furnished milk, which is a fluid, while the parents' food is solid. This seems to be different than in the case of young birds which receive solid food, but in the stomachs of these young animals is found *rennet*, a substance that changes milk into a solid or semi-solid condition. Junket is a familiar example of cow's milk turned into a solid.

It has been stated that rennet seems to be a superfluous substance in the stomach, seeing that the milk is again

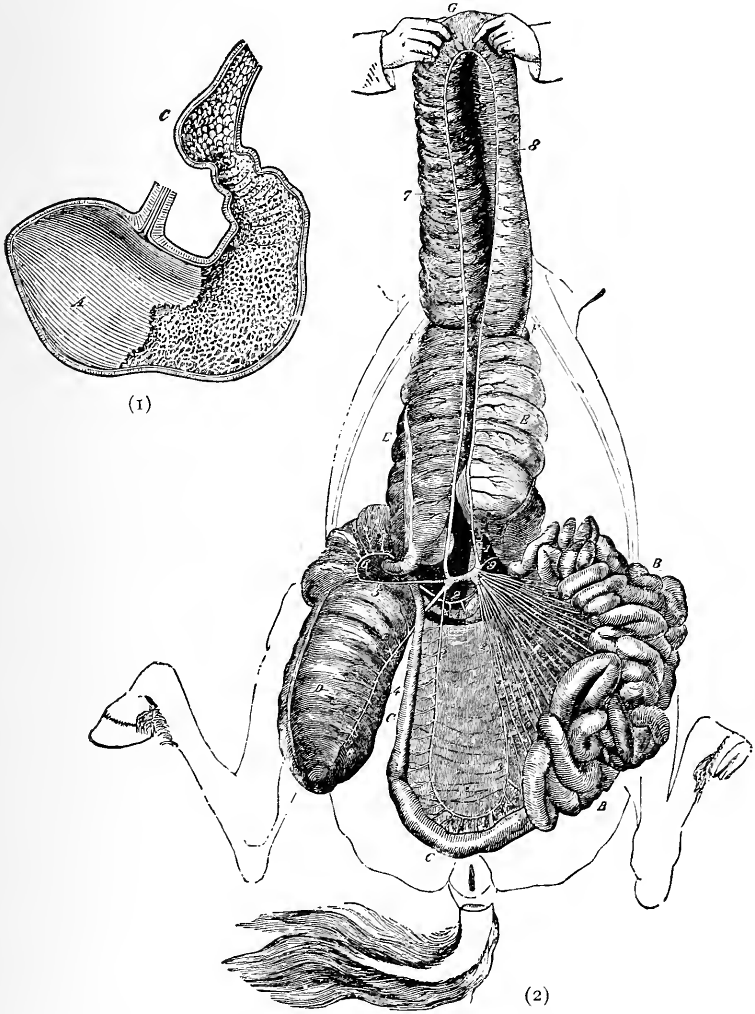


FIG. 6.—Complicated Digestive Tract of Horse. (1) Stomach, eight to nine per cent. (2) Intestines, ninety-one to ninety-two per cent. (Chauveau)

converted into a fluid by the digestive process, but that this is not so will be seen presently.

While *chemical analyses* show all milks to be alike in containing the same ingredients, but in different proportions, milks differ in their behavior with rennet, and as chemical analyses give so little information as to the character of the milk, chemists classify milks according to their behavior with rennet. It is found that cow's, goat's, and sheep's milk form solid curds when acted upon by rennet, which even when broken up into fine particles will readily unite again; while horse's and ass' milk form a fluid jelly which will not become solid. Human milk seems to stand between these two types of milk.

The greater part of the digestion of cows, goats, and sheep is performed in their stomachs, which, as stated before, comprise about seventy per cent of their whole digestive system. In changing the milk of these animals into a solid that cannot easily leave the stomach, the rennet causes the digestion of the young animal to take place in its stomach, the same as in the case of the parent.

The stomach of the horse or ass, being only eight or nine per cent of the digestive tract, will not hold enough food for a meal, and the outlet to the intestine is large, so the food can easily leave the stomach, which it does continuously during a meal. The milk of the horse or ass does not form a solid lump, but a fluid jelly that can readily be forced into the intestine, which comprises ninety per cent of the digestive tract. Here again it is plain that the mother's milk is exactly suited physically to the digestive tract of the young animal, and that the process of digestion of the young animal is similar to that of the parent.

In human beings, which eat meat and vegetable sub-

stances, the digestive system is adapted for either class of food, but the food must be prepared for digestion by thorough chewing of meat and by cooking of vegetable substances, as no paunch or enlarged intestine is furnished where they may lie and soak preparatory to digestion.

The human stomach, which comprises about *twenty per cent* of the digestive tract, is provided with a small outlet to prevent lumps passing into the intestine. This small outlet, teeth for dividing every kind of food, and salivary glands that secrete more fluid than the kidneys, show that the stomach was intended to receive soft, finely divided material which could easily pass into the intestine. If any proof of this conclusion was needed, the distress that is often brought on by hasty eating and bolting great lumps of food would furnish it.

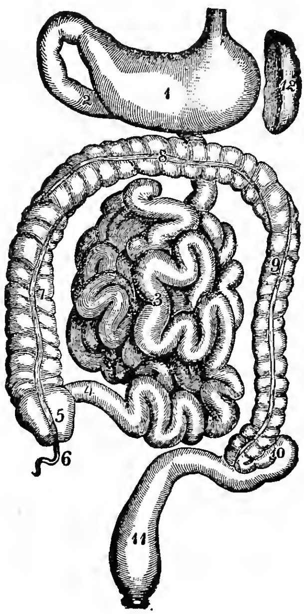


FIG. 7. — Human Digestive Tract. Stomach, twenty per cent. (Leidy.)

Human milk does not form a solid lump or fluid jelly in the stomach, but a soft, finely divided mass.

A whole book could be written showing instances of how nature adapts an animal to its surroundings and food, but from the few instances cited, which bear particularly on the feeding of young animals, it will be clear that, in

physical properties at least, there are different kinds of milk and that these differences are not freaks of nature or inexplicable, but are of the highest importance *in developing the young animal's digestive system;* also that milks are not interchangeable from a digestive standpoint. These physiological comparisons throw a strong side light on the difficulties necessarily met with in utilizing the natural food of one species for the nutriment of another.

In a future chapter the *composition* of milk will be discussed and an attempt will be made to show that the difference in composition of the milk of various animals is closely connected with the natural development and growth of the young animals.

Before this subject is taken up, a little space will be devoted to the chemistry of food and digestion.

CHAPTER V.

BROAD CLASSIFICATION OF FOOD INTO PROTEIN, FAT, CARBOHYDRATES, MINERAL MATTER, AND WATER.

7. Food is generally divided into four great classes:

I. Protein, often called proteid or albuminoids.

II. Fat.

III. Carbohydrates.

IV. Mineral matter or salts. In addition to these, water is a very important ingredient of food, as it enters into the composition of every part of the body, the bones even being over ten per cent water. There are many other important ingredients of food, but they are not generally considered, as they are usually found with one of these four classes. The function of the protein of food is to build up muscular tissue; fats and carbohydrates are heat-producers, and mineral matter hardens the bones.

I. *Protein.* The exact composition of protein or proteid has never been discovered, but it has been found that the different forms consist of:

Carbon	50.6 –54.5	per cent.
Hydrogen	6.5 – 7.3	"
Nitrogen..........(average about 16 per cent.)	15.0 –17.6	"
Sulphur	0.3 – 2.2	"
Phosphorus	0.42– 0.85	"
Oxygen	21.5 –23.5	"

Iron is also found in some forms of protein.

These figures in a general way represent the composition of lean beef, pork, mutton, veal, fowl, fish, and of

the total proteid of milk and eggs. Vegetable proteids seem to have about the same composition and chemical properties as animal proteids (4).

II. *Fats* are entirely different from proteids in composition, being composed of about:

Carbon	76.5 per cent.
Hydrogen	12.0 "
Oxygen	11.5 "

III. *Carbohydrates* form the chief portion of the dry substance of the vegetable kingdom.

The principal carbohydrates that are the natural food of animals are starch, found in potatoes and in nearly all the grains, and cellulose or the framework of plants.

For human food, *starch*, in the form of cereals and bread; *glucose*, found in grapes, raisins, molasses, and syrup; *cane sugar*, or the familiar granulated sugar, which is found in sugar cane, beets, carrots, and the maple tree; and *milk sugar*, found in milk, are the principal carbohydrates used. All these are composed of carbon, hydrogen, and oxygen, there being two parts of hydrogen for each part of oxygen, which is the proportion in which these elements combine to form water, H_2O. Hence the carbon is hydrated, and the name carbohydrates.

Cellulose	consists of	$C_6H_{10}O_5$ or $C_6(H_2O)_5$
Starch	" "	$C_6H_{10}O_5$
Glucose	" "	$C_6H_{12}O_6$
Cane sugar	" "	$C_{12}H_{22}O_{11}$
Milk sugar	" "	$C_{12}H_{22}O_{11}$

Chemically the only difference between all these carbohydrates is the quantity of water (H_2O) combined with the carbon. Physically there are great differences. Milk sugar and cane sugar, which have the same composition,

are different from each other, as also are cellulose and starch.

IV. *Mineral matter* is found in all forms of food, but it is hard to tell much about the state or combination in which it exists.

8. In comparing the composition of proteids, fats, and carbohydrates, it will be noticed that the proteids are very complex and contain a fairly constant percentage of nitrogen, which is not found at all in the fats and carbohydrates. As proteid takes such a variety of forms, the only practical method of determining it quantitatively is to determine the quantity of nitrogen in the food and consider it sixteen per cent of the total proteid, as all proteid contains about sixteen per cent of nitrogen. The weight of proteid is found by multiplying the weight of the nitrogen by 6.25 (16 per cent $\times$ 6.25 = 100).

It is not pretended that this method is exact, but it is the best that can be devised and answers all practical purposes. The lecithin, which is a kind of fat, is included with the proteid, as it contains nitrogen.

Fats are determined by extracting the food with ether or other fat solvents.

Carbohydrates cannot be determined directly. It is customary in most food analyses to determine proteid, fat, water, and mineral matter, add their weights together, and call the remainder carbohydrates.

Mineral matter is determined by burning some of the food and weighing the ash.

9. It is easy to see that a mere chemical analysis is not a safe guide in selecting a food for an animal, for a dog could not, on account of its simple digestive system, get

at the protein or fat of whole corn, for instance. It would starve with a stomach full of food that would nourish if it could only digest it; after the corn was ground and cooked, the dog could digest it. This has led to a *physiological* test to see how much of a certain kind of food each species of animal can digest and assimilate. A meal is weighed, and the fat, proteid, carbohydrates, and mineral matter are determined. The animal is then given a capsule of lampblack and a little later is fed the meal; before the next meal another capsule of lampblack is given. The discharges from the bowels are collected, and what is between the two lampblack marks contains what was left undigested from the meal. This excrement is analyzed and the digestibility of the meal determined.

By this method some old theories of feeding have been completely upset, for it had been assumed that many foods were just what was needed because chemical analyses showed them to contain large quantities of nutritious substances. Digestion tests, however, showed that they were not digested, and so of course there was no advantage in using the foods. A great many of these tests have been made on farm animals, and the following analysis will give an idea of the results:

	Water. Per cent.	Ash. Per cent	Protein. Per cent.	Carbo-hydrates. Per cent.	Fat Per cent.
Timothy grass contained........	61.6	2.1	3.1	32.00	1.20
" " " digestible	61.6	?	2.28	23.71	.77
" hay "	13.2	4.4	5.9	74.00	2.5
" " " digestible	13.2	?	2.89	43.72	1.43
Oats contained	11.0	3.0	11.8	69.2	5.0
" " digestible........	11.0	?	9.25	48.34	4.18
Cow's milk contained...........	87.2	0.7	3.6	4.9	3.7
" " " digestible ..	87.2	?	3.48	4.7	3.7

CHAPTER VI.

THE CHEMICAL PROCESSES OF DIGESTION—COMPARATIVE DIGESTION AND ABSORPTION IN DIFFERENT ANIMALS.

10. Before any food that is eaten can be of use to the organism it must be chemically changed so that it can pass into the blood in suitable form. Each animal is furnished with digestive juices that produce the requisite changes in its natural food, but just what these changes are or how they take place is not thoroughly understood. The kind of digestive juice that is secreted depends largely on the food that is eaten. In the lower forms of animal life, as the jelly fish, which folds itself around its food, it is found that if animal food is taken, a digestive juice that will digest meat is secreted; if vegetable food is taken, a digestive juice that will digest vegetable substances is secreted. As it was shown (6) that the more complex the food of an animal is, the more complex is its digestive system, so it will be found that the more complex the digestive system, the greater number of digestive juices there are secreted, each distinct portion of the digestive tract having a peculiar digestive juice particularly adapted to the condition of the food when it reaches it.

In animals that live on flesh, a strong juice that dissolves meat and even bone is found in the stomach. The food does not need to be chewed or moistened before

swallowing, and consequently little saliva is secreted. Here digestion is simple and the digestive tract is correspondingly simple (see Fig. 3).

When it comes to herbivorous animals, like the cow, goat, and sheep, the digestive system becomes exceedingly complex (see Fig. 4). When hay is eaten it must be softened, and the ox secretes ten to twelve gallons of saliva a day; when grass is eaten, only one-third as much saliva is secreted. The food of these three animals goes to the paunch or rumen and soaks until the cellulose (crude paper) that envelops the nutritious portions of the food is softened and partly digested when the food is regurgitated and rechewed, and then passes into the true stomach where digestion principally takes place. In birds with crops and gizzards practically the same process is observed. The goat's fondness for bill posters and labels is not altogether the result of degeneration. It can digest part of the paper and all the flour paste on it.

With the horse, mule, and ass, which eat the same kind of food as the cow, goat, and sheep, the *order* in which the digestive juices act is different. Their food is chewed with the saliva before it is swallowed, and the exposed portions that are easily digested are dissolved and the remainder of the food is passed into the cæcum at the far end of the intestine (see Fig. 6), which holds as much as a cow's paunch, where the cellulose is partly dissolved, allowing the enclosed nutriment to be then digested. With cows, etc., digestion takes place principally at the beginning of the digestive tract; with the horse and ass, at the end of it.

It might be truthfully said that the great difference in

the food of animals (for all must have protein, fat, carbohydrates, and mineral matter) lies in the fact that the food of herbivorous animals is wrapped up in cellulose (paper), while the food of carnivorous animals and human beings is not enclosed in cellulose. After this wrapping is removed from the food there is very little difference in the ability of different species of animals to produce the necessary chemical changes in the same food. Nature is very elastic on the food question, and in selecting a diet it is not so necessary to pay attention to fine points as to whether the food contains all the necessary elements and to their physical condition. Human beings cannot take their animal food in huge pieces as do carnivorous animals, nor their vegetable food in the form herbivorous animals find convenient. Meat must be chewed and vegetable substances cooked to break open the envelopes of cellulose. Each little starch grain has a coat of cellulose on it, upon which the human digestive juices have little action. Cooking starch by boiling or baking, as in bread, breaks these coats open and then the starch is readily digested (**103**, **105**).

11. The chemical changes in the food are brought about by *enzymes* found in the digestive juices. These enzymes have never been isolated in a pure state, and what they are is not known. Their presence can be detected only by their action on food. There seems to be a particular kind of enzyme for each kind of food.

In human saliva is found ptyalin (diastase), which converts cooked starch into dextrin and maltose. In the gastric juice is found pepsin, which is secreted along with hydrochloric acid, which converts proteid into albumoses

and peptones. Gastric juice has a strong solvent action on the connective materials that bind the muscular fibres together and causes meat to swell up and disintegrate into fine particles.

The greater part of human digestion is performed in the intestine, so the action of the saliva in digesting the exposed starch and the action of the gastric juice in disintegrating the connective material of meat and vegetable proteids are preparatory to intestinal digestion and must be important.

Fat, sugar, and starch are not acted upon by the gastric juice, and when present in excessive quantities interfere with its secretion. Fat and starch, by coating proteids, prevent the action of the gastric juice and throw the work of the stomach on to the intestines. Soaking bread in tea or coffee or washing down food with water does away with the action of the saliva on the starches, and frying food coats it with fat so that neither the saliva nor gastric juice can well act on it. Pork, on account of its containing so much fat, is particularly indigestible.

In the intestine are found enzymes that will convert proteids into albumoses and peptones, but intestinal digestive juice does not cause proteid to swell up and disintegrate first, as does the gastric juice; starch that escaped the action of the saliva is converted into dextrin, maltose, and dextrose; cane sugar into dextrose and levulose; and milk sugar into dextrose and galactose. As far as chemistry shows, all these changes consist of the chemical addition of water to the original proteid or carbohydrate. The actual changes have never been discovered. There are also found in the intestine enzymes that split and

emulsify fats. Some of these enzymes are secreted by the pancreas, and others by glands of the intestines.

These enzymes seem to act by contact, and to act best, the food must be finely divided and pulpy. Their digestive power is enormous. One part of crude *invertase* digested one hundred thousand times its weight of cane sugar, and was still active.

12. The process of human digestion differs from that of the lower animals, in that the vegetable food must be prepared outside of the body to rupture the cellulose envelopes, and the animal food chewed. The food then is to be first treated with a starch-digesting fluid, the saliva, to expose the proteid; next with the gastric juice which disintegrates proteid and reduces it to a pulpy jelly, and then only will the pylorus naturally open to allow food to pass into the intestine, where the greater part of the *chemical* changes in the food take place previous to absorption.

13. The secretion of the digestive juices is under the control of the nervous system. The thought of an appetizing meal makes the mouth water, and the food is then pretty apt to be digested. Pleasant-tasting food taken into the mouth also excites the secretion of the digestive juices.

The absorption of certain substances from the digestive tract strongly excites the secretion of all the digestive juices. Among the substances that act as promoters of digestive secretion are the products of salivary digestion of starch (dextrin and maltose), and the *extractives* of meat (2). Substances which have the power of stimulating digestive secretion are also found in milk.

14. The process of digestion is laborious at the best, one-sixth of the entire force of the organism being required to digest an average meal; so an indigestible meal that requires prolonged digestive secretion, or has to be digested in the intestine without preparation in the mouth and stomach, causes great weariness.

Excessive quantities of fat in the stomach retard not only the digestion of proteid by coating it, but also retard the secretion of the gastric juice and cause loss of appetite. Excessive quantities of sugar cause the stomach to secrete an unusually acid gastric juice, which interferes with digestion. These two facts should be remembered, as they have great practical value in infant feeding.

Nervous shock or excitement interferes with normal digestive secretion.

15. Just how much of each of the digestive juices is secreted is not known, but an adult secretes more saliva than urine. There seems to be a continuous flow of digestive juice and absorption of digested food during the process of digestion. The process of absorption of proteid is not known. Some change takes place in the digested proteids during their passage through the walls of the digestive tract into the blood, for the products of proteid digestion are not found in the blood, and if injected into the blood are eliminated unchanged by the kidneys. Fats are emulsified and absorbed with little change.

16. After the digested food has passed from the digestive tract into the blood, it must be carried to the cells in every part of the body. This does not take place suddenly but gradually. Those portions of the digested food that are not immediately required are stored up for future

use. The excess of carbohydrates is stored away in the muscles and liver in the form of glycogen, which is similar in composition to starch; a great excess of carbohydrates is eliminated by the kidneys or converted into fat. Excess of fat is stored away as fat. Proteids are not stored up in the adult, any excess being excreted, as will be explained in the next chapter.

17. When an animal is not fed at all, the processes of life continue for a certain time, but there is a steady loss of weight. The glycogen stored in the liver disappears almost completely; the stored-up fat also disappears, and all the muscles shrink away, and at last the animal dies.

For a long time it was not known how the tissues fed upon themselves, but it has been recently discovered that in the blood there are enzymes that will digest glycogen or animal starch, converting it into dextrin, maltose, and dextrose, which is then carried to the portions of the body where it is most needed and again converted into glycogen. This is found to be the case even in the fœtus. This same process must take place with fats and proteids, but the enzymes that produce the changes or what is the nature of the changes in the proteids have not been discovered.

These enzymes that act in the system are called enzymes of translocation, and have somewhat different modes of action from those of the digestive enzymes. They have been better studied in the vegetable kingdom, and their action can readily be appreciated by watching a potato sprout in a dark cellar or in the changing of a sprouting pea or a bean into root, stem, and a pair of leaves.

CHAPTER VII.

METABOLISM AND EXCRETION.

18. The process by which the digested food is built up into living tissue, and the living tissue and food are reduced to other and simpler dead forms, is called *metabolism*. This process is going on continually in the organism; the object of food is to replace the loss caused by destructive metabolism and to build up new tissue. There can be no scientific feeding without a knowledge of the functions of each kind of food, how it is changed in the organism, what are its by-products, and how they are excreted.

19. Fats and carbohydrates composed of carbon, hydrogen, and oxygen are *completely* burned in the body by the inhaled oxygen of the air, into carbon dioxide and water, which are excreted principally through the *lungs*. These two food principles are mostly used as *fuel* to supply the necessary heat to keep the body warm and furnish living force.

Proteids can also act as fuel, but are *incompletely burned* in the body. The carbon dioxide produced in the metabolism of proteid is thrown off by the lungs, but the distinctive by-products of proteid metabolism are carried off by the *urine* in the form of urea, uric acid, phosphates, sulphates, and other salts; so a study of the urine is very important.

20. In practice, to determine the quantity of proteid

that is being actually consumed in the body, it is only necessary to determine the quantity of nitrogen in the urine and multiply by 6.25 (8), which gives the weight of the proteid. It is a singular fact that in an *adult* animal there is what is called a *nitrogenous equilibrium*—that is, the amount of nitrogen eliminated equals the amount taken in as food. If the fats and carbohydrates are fed in excess of the requirements of the body, they are generally stored up as fats, but with proteids it is different; an increase of proteid in the food produces an increase in the quantity of nitrogen in the urine, and in a few days the quantity of nitrogen excreted equals the quantity taken in as food. Possibly the excess of proteid is not all wasted, it may be partly changed into fat, but the only way an increase of proteid in the body can be brought about in an adult is by *muscular activity*, which increases the size of the muscles. Inactivity increases fat. Activity decreases fat and increases proteid up to a certain point. Growing animals that are laying on proteid are full of activity and playful, which they cease to be, as a rule, when fully grown.

21. The amount of nitrogen that is eliminated in the urine depends on the animal's food; the urine of carnivorous animals is rich in nitrogen, while the urine of herbivorous animals is poor in nitrogen, which shows that in the flesh-eating animals large quantities of proteid are being consumed as fuel, while in the vegetable-eating animals, whose food is principally carbohydrates, small quantities of proteid are thus consumed.

22. When animals are starved they immediately commence to live on their own flesh and become carnivorous.

Experiments made with metabolism during starvation show that the urine of the herbivorous animals becomes the same as that of the carnivorous animals in every way. The stock of carbohydrates (glycogen) that is stored up in the liver of all animals disappears after a few hours of starvation, and then the fat and proteids begin to disappear.

During starvation the temperature of the animal remains about the same as in health, and the amount of nitrogen in the urine, while less in quantity, is the same in proportion to the weight of the animal as it was in health in the case of carnivorous animals, and greatly in excess of the quantity in health in the case of herbivorous animals whose diet is principally carbohydrates. Hence herbivorous animals do not stand starvation so well as the carnivoræ. Metabolism is very active in young animals. Children die of starvation after about four or five days, while adults can often starve twenty days without lasting injury.

Just before death from starvation the quantity of nitrogen in the urine increases greatly; then the temperature drops below normal, and the animal dies—the fire has gone out. Upon examination of the animal it is found that all the fat of the body has disappeared, even the bones having lost, and the proteid has been drawn on until the muscles of the heart are too weak to act. The increase of nitrogen in the urine just before death marked the time when all the fat had been used up and the proteid had to be drawn on exclusively for fuel.

23. If a starving animal is fed carbohydrates or fats the quantity of nitrogen eliminated in the urine is greatly re-

duced and the animal loses weight less rapidly, but eventually dies, as these food elements cannot be converted into proteid and there is always a certain consumption of proteid. Fats and carbohydrates are proteid sparers, carbohydrates being more effective than fats. The knowledge of how to take advantage of this fact is of great value in the treatment of diarrhœa and fevers in which there is increased destruction of proteid with decreased elimination of urine, and in kidney affections in which the urea cannot be eliminated normally.

24. If a healthy carnivorous animal is fed albumin (white of egg), which is a form of protein, it will die from starvation in about two months. Death from starvation will also follow if fats and carbohydrates are fed along with albumin, fibrin, or gelatin, which are all forms of protein. Attempts at separating different forms of protein for food purposes are not to be recommended, as grave errors in nutrition are likely to be the result. This much is known: the protein found in meat, whole milk, grass, and cereals, when given in the original state without attempts at separation into distinct classes or forms, will support life and produce good healthy tissue; but just what part each form of protein plays in nutrition is not known. The form of fat and carbohydrate can be changed with little or no ill effect, but to assume if a form of food which contains sixteen per cent nitrogen and is digestible is given for protein that perfect nutrition will follow, is a policy that may lead to anæmia, rickets, or other forms of malnutrition.

25. It will be seen from the foregoing that the functions of the fat and carbohydrates of the food are principally to

supply heat and living force, and those of the proteid to build the growing tissue and to repair waste; also that when the waste in the tissue has been made good from the food, the excess of proteid in the food is burned and eliminated and not stored up as proteid in the *adult*. From a fuel standpoint, fat, carbohydrate, and proteids are interchangeable in about these proportions: fat, 2¼; proteid, 1; carbohydrate, 1; but from a tissue-building standpoint they are not. This knowledge has led to the use in animal feeding of what is called a balanced diet; that is, a diet which contains enough digestible fat and carbohydrates to furnish heat, and enough proteid to prevent a loss of proteid tissue. This point is determined by finding whether the nitrogen in the proteid of the food equals the nitrogen in the urine. The amount of proteid required in the food depends largely on the animal. Wool-producing animals, as the sheep and goat, need more proteid than is actually used in the vital process in order to form the wool and hair; and milk-producing animals need more proteid in the food than those of the same species that are not secreting milk, as from three to four per cent of the milk is proteid. In an adult animal it is a waste to give much more nitrogen (proteid) in the food than is found in the urine during a period of fasting under the same conditions of living, as the only result is to throw extra work on the digestive and excretory systems with no gain to the organism. With children and young animals there should be more nitrogen (proteid) in the food than is found in the urine, as they need it to produce new growth of tissue, and true growth consists of increasing the quantity of proteid in the body.

26. In artificial infant feeding the great difficulty lies in supplying proteid suitable to the infant's needs and digestion, and the great temptation is to cut it down in quantity or supply it in forms that are very easily digested. The result is that either not enough proteid to produce much healthy growth is furnished, or a large quantity of a form of proteid that cannot do more than retard the infant's consumption of its own tissue is given, and a poorly developed child is often the result. This is an error that is almost sure to result from a diet based simply on a chemical analysis.

27. During the process of digestion there is a greatly increased destructive metabolism of carbohydrates, fully fifteen per cent greater than in fasting under the same conditions, and also a slight increase in the destructive metabolism of proteid. Examination of the glands secreting the digestive juices shows that they absorb lymph, which is in some way changed into digestive juice and then secreted. Here is a source of slight loss of proteid during digestion, for this proteid matter is not all absorbed, but goes in part to make up *fecal matter*. It is supposed by many that the fæces consist of undigested food. This is true to but a slight extent. Fecal matter consists almost wholly of secretions from the digestive tract. The intestines of a new-born infant contain fecal matter—meconium. A starving animal produces fecal matter similar to meconium, and a perfectly clean loop of the intestine will secrete feces.

The character and quantity of the fecal matter depend largely on the food that is eaten. On an exclusive meat diet it is scanty, black, and pitch-like, and quite sim-

ilar to that from a starving animal, which is living on its own tissues. When fat is added to the food the fecal matter contains fat and is lighter in color. When vegetable substances are added to the diet the quantity of fæces increases and the color changes with the character of the food. The increased quantity consists in part of undigested food, but principally of the increased secretions of the mucous membrane of the intestine, caused by the coarseness of the food and the mechanical action of the undigested portions.

In health the color of the fecal matter depends on the kind of food. Bile pigments, calomel, and senna produce a green color, iron and bismuth a black, and rhubarb a yellow color.

In normal digestion of human beings there should be little undigested food in the fecal matter, so an examination of the stools is of the greatest importance in feeding infants—in fact, is absolutely essential to success (156).

CHAPTER VIII.

COMPARISON OF THE MILK OF DIFFERENT ANIMALS. CHEMICAL AND PHYSIOLOGICAL DIFFERENCES.

28. THE milk of all animals must contain the materials necessary for the nourishment of their young. Chemical examination of milks shows them all to agree in containing water, fat, proteids or albuminoids, carbohydrates, and mineral matter. In addition to these ingredients, lecithin, cholesterin, citric acid, and other substances are found in varying proportions.

The present knowledge of the chemical composition of milk can be best appreciated by the following quotations from recent high authorities upon the chemistry of milk:

"Our present knowledge of the albuminoids of milk is far from complete, though much work has been done on the subject. This is due to the fact that it is extremely difficult to obtain these compounds in anything like a state of purity. . . . As there is no means of knowing when all the impurities have been eliminated, it is possible that we are yet unacquainted with the albuminoids of milk in a state of purity. This should not be forgotten during the study of the milk albuminoids.

"In the albuminoids, the milks of different animals differ greatly. They may be divided broadly into two

classes—those which give a curd on the addition of an acid, and those which do not. In the first class are included the milk yielded by the cow, the goat, the gamoose, etc.; and in the second, human milk, that of the mare and the ass may be cited as examples. In the first class the curd is composed of casein, which is combined with phosphates of the alkaline earths; while in the second this is replaced by a similar albuminoid, which is not, however, combined with phosphates. It is possible that the difference between the albuminoids of the two classes is simply dependent on the presence or absence of the phosphates; but the chemistry of these bodies is only in its infancy, and it would be premature to offer an opinion at the present time. Besides casein, or a similar body, there exists in all milks a second albuminoid called *albumin;* this differs from casein by not being precipitated by acid, and by being coagulated by heat. Other albuminoids have been described in milk, but many of them are only decomposition products of casein or albumin, which were formed during the process adopted for the removal of the other albuminoids. . . .

"The sugar in milk is of a peculiar nature; that of cow's milk is called "lactose," or, more commonly, sugar of milk. It is generally assumed that all milks contain the same sugar, but of this there is some doubt. . . .

"The sugar of the milk of the mare has the property of easily undergoing alcoholic fermentation, a property not possessed by lactose. According to the experiments of Carter and the author, the sugar of human milk is not identical with that of the milk of the cow" (Richmond).

"The nitrogenous constituents of milk are very un-

stable compounds and their study presents many and great difficulties; as a result we find that no two scientists who have made a special study of these compounds agree as to their properties, aside from those of casein and albumin, or their relation to the nitrogenous substances found elsewhere in the animal body" . . . (Farrington and Woll).

"The milk fat has rather variable specific gravity, which according to Bohr is 0.949–0.996 at + 15° C. The milk fat, which is obtained under the name of butter, consists in great part of the neutral fats *palmitin*, *olein*, and *stearin*. Besides these it contains, as triglycerides, *myristic acid*, small quantities of *butyric acid* and *caproic acid*, traces of *caprylic acid*, *capric acid*, *lauric acid*, and *arachidic acids*. . . . Milk fat also contains a small quantity of *lecithin* and *cholesterin*, also a yellow *coloring* matter. . . .

"The milk plasma, or that fluid in which the fat globules are suspended, contains several albuminous bodies, *casein*, *lactoglobulin*, and *lactalbumin*, and a little *opalisin*, and two carbohydrates, of which only one, the *milk sugar*, is of great importance. The milk plasma also contains extractive bodies, traces of *urea*, *creatin*, *creatinin*, *hypoxanthin* (?), *lecithin*, *cholesterin*, *citric acid* (Soxhlet and Henkel), and lastly also *mineral bodies* and *gases*" (Hammarsten on cow's milk).

It will be readily seen that an analysis of milk that took into consideration all its minor ingredients would be an exceedingly complex process and to a certain extent a needless one; as a matter of fact there has never been a process of complete analysis of milk worked out.

The usual method of analysis is to evaporate a speci-

men of milk to dryness and call its weight *total solids.* What ether will extract from "total solids" is called *fat,* although the lecithin is also included. The *total nitrogen* in the milk is determined and its weight multiplied by 6.25 (8) and called *proteid.* In this proteid is again included the lecithin as it contains a little nitrogen. A portion of the total solids is burned and the weight of the ash in the milk is calculated as *mineral matter.* The weights of *water*, *fat*, *proteid* and *mineral matter* are added together and *subtracted* from the weight of the milk and the difference called *carbohydrates* or *sugar.* This method is not exact, but answers all practical purposes in ordinary methods of calculating food values.

Methods of determining casein and albumin in milk consist of adding acid which precipitates the casein but not the albumin; the casein is removed by filtration and the filtrate is boiled, which precipitates albumin; the nitrogen in each is determined and multiplied by 6.25. When the weights of the casein and albumin so determined are added together there is not as much total proteid as when the nitrogen in the whole milk is determined and multiplied by 6.25.

According to A. Winter Blyth, an English authority on food, the casein of woman's, mare's, and ass' milk separates only with great difficulty, and then not completely, upon the addition of acids. This may and probably does account for the small quantity of casein reported in woman's milk by some chemists and the larger quantity obtained by others who employed different methods of analysis. This subiect will be alluded to in another place (145).

No method of quantitatively determining the sugar in milk has been devised. It is either determined "by difference," or rotation of a ray of polarized light, or by the reduction of alkaline copper solution. The quantity of sugar present in a specimen of milk varies slightly with the method of determining it.

29. The composition of any kind of milk varies a great deal and it is customary to speak of *average milk*. The composition of average milk is determined by adding together a great many analyses of milk and dividing the sum by the number of analyses. It may be that the resulting composition of milk may have never been actually met with. In speaking of woman's milk Hammarsten says: "Even after those differences are eliminated which depend on the imperfect analytical methods employed, *the quantitative composition* of woman's milk is variable to such an extent that it is impossible to give any average results"; and of the milk of other animals,—"To illustrate the composition of the milk of other animals the following figures, the compilation of Koenig, are given. As the milk of each kind of animal may have a variable composition, these figures should be considered only as examples of the composition of milk of various kinds:"

Milk of the—	Water.	Solids.	Proteids.	Fat.	Sugar.	Salts.
Dog	75.44	24.56	9.91	9.57	3.19	0.73
Cat	81.63	18.37	9.08	3.33	4.91	.58
Goat	86.91	13.09	3.69	4.09	4.45	.86
Sheep	83.50	16.50	5.74	6.14	3.96	.66
Cow	87.17	12.83	3.55	3.69	4.88	.71
Horse	90.06	9.94	1.89	1.09	6.65	.31
Ass	90.00	10.00	2.10	1.30	6.30	.30

From the analytical figures just given it might readily be inferred that the great difference between milk of all

animals lay in the different percentages of water, proteids, fat, sugar, and salts, but a glance at the following analyses of cheeses made from milk with which all are familiar will show what a grave error such a conclusion would be if applied to cheese:

	Water.	Fat.	Proteids.	Ash.
Ordinary cheese (made of cow's milk) ..	27.20	32.05	36.60	4.15
Roquefort cheese (made of sheep's milk)	26.50	32.30	32.90	4.4

30. Chemists have recognized that for anything but comparison of potential food values, analyses of milk are valueless, and have classified milks according to their curding properties.

All milks contain *at least* two forms of protein: casein, or, as it is called by some writers, caseinogen, and albumin, while some milks contain a large proportion of other forms of protein.

Casein of cow's milk is easily precipitated by cold dilute acids, while albumin is not. The curds of sour milk consist principally of precipitated casein. If an alkali is added to neutralize the acidity of sour milk the casein assumes its original form. However, the precipitation, or curding of milk, by the addition of acids is not the physiological curding of milk. In the stomach of animals is found an enzyme—rennet—which clots milk very much as blood is clotted, and the character of this clot depends on the kind of milk that is used.

31. The clotting of milk by rennet is an entirely different process from the precipitating of casein by acids or the souring of milk. Cow's milk is changed by rennet into a solid, which shrinks into a leathery, stringy mass that

contains the fat of the milk embedded in the meshes of the curd. The albumin and other protein bodies and the sugar of the milk are squeezed out as "whey." Horse's and ass' milk form a very soft, gelatinous curd with rennet, and woman's milk forms finely divided curds.

Even after the milks are classified according to their curding properties there are great differences in the composition of the milks which need to be explained. Now, if instead of making the chemical analyses or curding properties of the milks the bases of comparison, the milks are classified according to the natural order of the animals producing them, the reason for the wide differences in milks will appear, and each milk will be seen to be specially adapted in composition and curding properties to the rate of growth and digestive system of the young animal it was intended to nourish (Chapter IV.).

Types of milk.	Animal.	Curds.	Water. Per cent.	Fat. Per cent.	Sugar. Per cent.	Proteids. Per cent.	Salt. Per cent.	Attains puberty in months.
Carnivorous (Stomach 60 to 80 per cent of digestive tract.)	Dog.	?	75.44	9.57	3.19	9.91	0.73	6–8
Ruminant Herbivorous (Stomach 70 per cent of digestive tract.)	Sheep	Solid	83.50	6.14	3.96	5.74	.66	6–8
	Goat.	Solid	86.91	4.09	4.45	3.69	.86	6–8
	Cow.	Solid	87.17	3.69	4.88	3.55	.71	8–12
Non-ruminant Herbivorous (Intestine 90 per cent of digestive tract.)	Mare.	Gelatinous	90.06	1.09	6.65	1.89	.31	18
	Ass.	Gelatinous	90.00	1.30	6.30	2.10	.30	18
Human (Stomach 20 per cent of digestive tract.)	....	Flocculent	88.20	3.30	6.80	1.50	.20	14 yrs.

It should be remembered that these milks vary somewhat in composition. (See **32 A**, for separate analysis of proteids.)

It will be noticed that the milk of carnivorous animals is exceedingly rich in proteids; that the milk of herbivorous animals, whose digestion is principally gastric, forms solid curds which cannot easily leave the stomach; that the milk of herbivorous animals, whose digestion is principally intestinal, forms gelatinous curds which easily leave the stomach and pass into the intestine; and that woman's milk, which was intended for a digestive system in which the gastric digestion is more than that of the horse or ass, but not so great as that of the cow or goat, curds in flakes which stand between the other two types of curds.

It is also remarkable how close to each other in type of composition the milks of different animals of the same class appear to be, and what a close relation there is between the composition of the milk and the rate of growth of the animal. It may be pointed out that the fat and proteid in ewe's milk are much greater in quantity than in goat's milk and greater in goat's milk than in cow's milk. At first sight there appears to be no reason for this, but there is. Sheep produce wool and goats produce hair which are made up of protein substance and fat. Over forty per cent of the weight of raw wool is of a fatty nature and this fat is found not in the wool fibre alone but mostly *on* it. It is the familiar lanolin or wool fat. Hair does not have much fat on it and goat's milk does not contain anything like the same quantity of fat as sheep's milk.

There is an apparent discrepancy between the composition of cow's milk and mare's milk and the rate of development of their young. It must be remembered

that cows have been bred for years for the purpose of producing milk, and those animals that did not produce rich milk have been rejected. The ordinary common stock of cows does not produce milk containing fat 3.69, proteids 3.55 per cent, as shown in the analysis, but nearer fat three per cent and proteids three per cent. The dairy laws in most of the States call for only three per cent of fat in milk. Horses and asses have not been bred so as to produce rich milk as have cows. When these facts are taken into consideration, the apparent discrepancy disappears.

32. *One* of the great differences between woman's milk and other milks, which is well known, but which is not shown in the analyses, is that woman's milk is richer in *lecithin*, which forms a large part of the brain and nerves. Within half an hour after birth a calf, lamb, kid, or colt can stand, and in a day or two runs around and sees, hears, and smells about as well as its mother. In other words, it is born with a fully developed nervous system. A baby is very different in this respect, and it needs material for building up its nervous system, and this is found abundantly in woman's milk, but not so much in other milks.

32 A. In all milks there is greater or less quantity of soluble proteid generally called albumin, although not nearly all albumin, which is not retained in the curd, but which separates with the carbohydrates in the whey (31). This soluble proteid is readily absorbed from the digestive tract. It was shown that during digestion there was a slight increase in proteid and a large increase in carbohydrate metabolism (27). The first step in the digestion of milk, it

will be seen, is a separation of easily absorbed proteid and carbohydrate, for which there is a great demand during digestion, from the casein and fat, which require more digestion and which are stored away in the growing animal as fat and muscle; and in another place it will be shown that the fat of milk is mostly secreted at the latter part of a suckling or milking (36).

32 **B.** The quantity and character of the soluble proteids of milk are of considerable interest in the comparison of milks. In 1897 Babcock and Russell discovered enzymes in milk which would digest its proteids *in time* if the bacteria present were destroyed by means other than heat, which destroyed the enzymes. To prove that the changes in the proteids of the milk were due to these enzymes. some very carefully conducted experiments and analyses were made.

The casein and albumin were removed from milk by heating with acetic acid and filtering. The character of the remaining nitrogenous compounds was then carefully investigated, and they were considered to be principally albumoses and peptones (11). The milks were set aside, and from time to time portions were analyzed to detect the rapidity of the digestive process which was found to be slow, months being required before it was half completed.

While the discovery of the presence of these enzymes in milk has no practical significance in infant feeding the analyses made in this connection are of the greatest value.

In the following analyses by Babcock, Russell and Vivian only the cow's and goat's milk were the mixed secretion of several animals. In another place (38) will

be found many complete analyses of the proteids of cow's milk.

Date.	Kind of milk.	Total N. Per cent.	Sol. N. Per cent.		Total proteid Per cent.	Albumoses peptones? Per cent.
December 4th, 1897.	Sheep	0.76	0.09	× 6.25 = (by author)	4.75	0.58
December 4th, 1897.	Sheep	.71	.10		4.43	.62
December 4th, 1897.	Sheep	.60	.10		3.75	.62
December 4th, 1897.	Sheep	.76	.09		4.75	.56
December 29th, 1897.	Sheep	.80	.10		5.00	.62
December 13th, 1897.	Human (From six different women.)	.28	.10		1.75	.62
February 1st, 1898.	Human	.28	.10		1.75	.62
March 8th, 1898.	Human	.27	.10		1.68	.62
May 2d, 1898	Human	.27	.09		1.68	.56
June 23d, 1898	Human	.28	.10		1.75	.62
July 1st, 1898	Human	.27	.10		1.68	.62
February 21st, 1898.	Goat	.78	.06		4.87	.37
April 20th, 1898	Pig	.72	.17		4.51	1.06
April 28th, 1898	Pig	.70	.16		4.37	1.00
December 29th, 1898	Mare	.28	.09		1.75	.56
February 21st, 1898.	Burro	.25	.10		1.54	.62
March 8th, 1898.	Half-bred buffalo	.48	.04		3.00	.25
	Cow	.51	.04		3.18	.25

It will not be difficult to see that the character of the proteids of milk cannot be told by the *usual* chemical analysis; that with improved methods of analyses different results are obtained, and that all young animals are not on a dead level when they are on a milk diet; also that it would be irrational to expect by a simple adjustment of percentages of fat, sugar, and proteids to make milks interchangeable, even from a chemical standpoint.

Having seen how little real help is to be derived from a chemical analysis of milk, it may prove interesting to glance at the place of milk in the animal economy. The material of which the young animal is composed is derived exclusively from the mother's body up to the time it is able to eat and digest the same food as the mother eats. All animals are not alike in regard to the manner in which

the nourishment for the young animal is supplied. It may be all supplied at one time in the form of an egg, which the germinal cell turns into a more or less fully

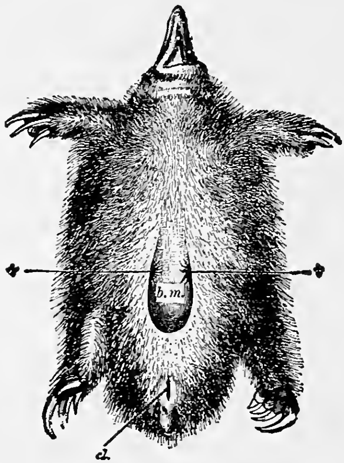


Fig. 8.—Mammary Pocket of Spiny Ant-Eater. (Wiedersheim.)

formed young animal, or it may be furnished gradually in small amounts. In the earliest stage of development of mammals the single cell is bathed in nutritive fluid; as it

Fig. 9.—Egg Laid and Hatched in Mammary Pocket shown in Fig. 8 and Resulting Fœtus. Life size. (Photographed from specimens in the Zoological Collection of Columbia University.)

grows more it either becomes attached to the uterine wall and develops a placenta and navel cord through which the nourishment is derived from the mother up to the time of

birth; or it is born in a poorly developed condition and grows fast to a teat, becoming a mammary fœtus. In this case nearly the whole development is made on the

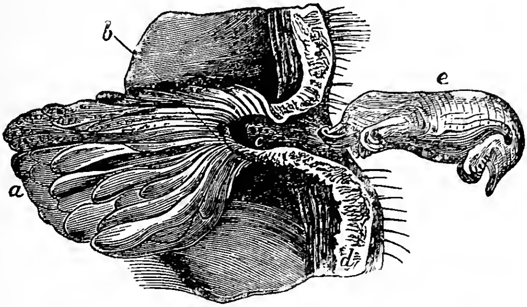


FIG. 10.—Mammary Gland and Fœtus of Spiny Ant-Eater. (Owen.)

FIG. 11.—Mammary Fœtus of Kangaroo in Pouch. Life size. (Photograph of specimen in Zoological Collection of Columbia University.)

teat, the mother ejecting the nourishment into a specially adapted gullet until the young is strong enough to suck.

Figs. 8 and 10 show an animal that lays eggs and suckles the young after hatching the eggs.

Figs. 11 and 12 show the mammary fœtus adherent to the teats.

At one time in the past the mammary fœtus was common, but is now becoming extinct. It is interesting in this connection only in showing that the infant during the nursing period should be looked upon as still being

FIG. 12.—Young of Opossum Adherent to Teats. Half life size. (Photographed from specimens in the Zoological Collection of Columbia University.)

physiologically attached to the mother, and that it is not naturally fitted for nourishment not derived from her body, as it is not fully formed.

In the early fœtal stages all animals are so much alike in all respects that it is practically impossible to determine one species from another species, as is shown by Fig. 13.

The digestive tracts are alike at first and simple tubes, but gradually develop into the more or less complex forms

of the adult. Fig. 14 shows development of human digestive tract and Fig. 15 the stomachs of a number of mammals.

The milk of the mother, by the curding of the casein in the stomach, develops the digestive tract of the young

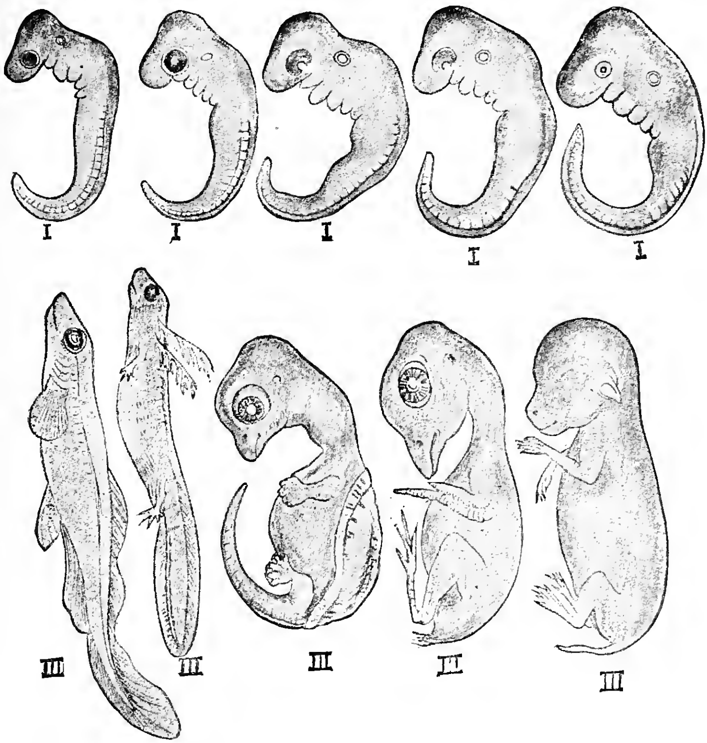


FIG. 13.—Earlier and Later Fœtal Stages of Fish, Salamander, Tortoise, Chick, Rabbit. (Haeckel.)

animal. The caseins of milk differ according to the type of digestive tract. Caseins behave in a peculiar manner when acted upon by the digestive juices, which make them the necessary basis of the artificial infant food. In the section on practical feeding this behavior of casein is explained in detail. Milks, therefore, have important prop-

erties other than simple food values, which cannot be determined by the chemist.

They have physiological properties which should be

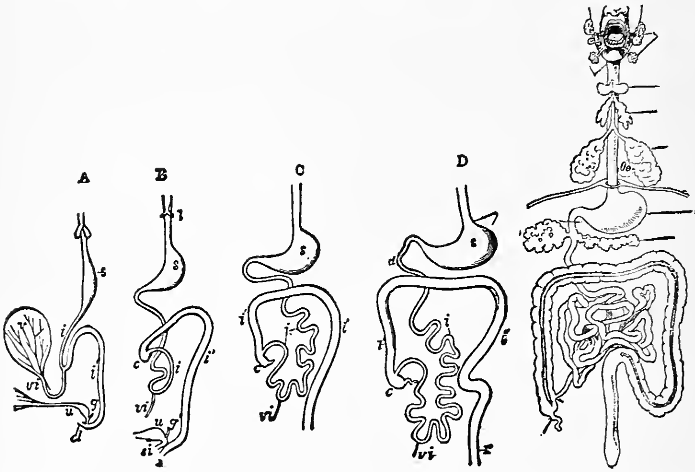


FIG. 14.—Development of Human Digestive Tract. (Allen Thomson and Wiedersheim.)

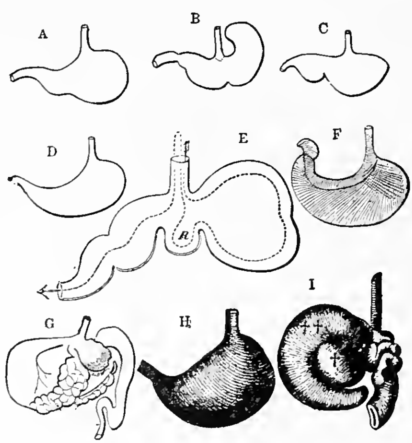


FIG 15 —Stomachs of Different Mammals. (Wiedersheim.) *A*, dog; *B*, rat; *C*, mouse; *D*, weasel; *E*, ruminant; *F*, *human;* *G*, camel; *H*, spiny ant-eater; *I*, three-toed sloth.

better understood and which are connected with the diversification of digestive tracts.

CHAPTER IX.

SUMMARY.

33. In the preceding chapters it was shown: (1) That all animals are alike in the chemical processes that take place within their organisms during starvation, and that the administration of digestible fat, proteids, or carbohydrates singly produces the same result in all kinds of animals. (2) While chemically there seems to be no difference between the different forms of animal life, physiologically there are vast differences, and these differences seem to be closely related to the food supply, all the organs and parts of the body of a particular kind of animal being adapted to enable it to secure and digest its natural food. (3) In the case of young animals which take milk it was shown that not only does the milk of different species of animals contain practically the same food elements in varying proportions and forms suited to the needs of each particular species, but that the milks possess different curding properties that make them particularly suitable to their rêspective digestive tracts, and that the process and order of digestion in the young animal are practically the same as those of the parent.

(4) It has also been shown that while the chemical composition of milks varies greatly, there is a *type of composition* for each distinct class of animals, also that the variations within these types are considerable; but that

in spite of these variations, each distinct type of milk has certain physiological properties that do not vary with the change in chemical composition or concentration of the milk. For example, poor or diluted cow's milk has the same curding properties as the rich milk of cows. (5) That the selection of a food for any animal cannot safely be made upon a chemical analysis only, but by the aid of a digestive test. (6) That some forms of proteid, even when digested, will not produce a healthy tissue, and that there are certain combinations of the various food principles or elements that must be made to suit each class of animals. As the chemistry of the animal tissues, ingredients of milk, and different foods is only in its infancy, and the functions of all the food elements are not thoroughly understood, it is useless to attack the problem of artificial infant feeding from the standpoint of chemistry alone, although a knowledge of food chemistry is of great assistance. What is needed is a knowledge of the substances that have proved to be able to support life and produce healthy tissue; how to combine and to adapt them to suit the needs and digestive system of the infant; the indications of malnutrition and faulty digestion, and how to spare tissue waste in disease by an alteration of diet.

In the following chapters the production and properties of raw food materials will be taken up and then the practical problems of infant feeding.

PART II.

CHAPTER X.

COW'S MILK.

34. *Colostrum.*—When the calf is born its digestive system has never been used and the cow's udder secretes a substance entirely different from normal milk, called colostrum, which seems to be designed to educate the calf's digestive system to digest food. Colostrum is composed of fat, sugar, proteids, mineral matter, and water, as is normal milk, but the character of the proteids and sugar is different from that of normal milk. The proteids of colostrum consist largely of albumins and globulins, and also albumoses and peptones, which are easily assimilated, and the sugar is said to be dextrose—the sugar found in the blood and not the milk sugar which is found in cow's milk.

The character of the udder secretion gradually changes, the albumins and globulins being replaced by casein and the dextrose by milk sugar. The albumins and globulins of colostrum will coagulate upon boiling just as does the white of egg. To determine when the udder secretion has become normal milk it is boiled and if it does not coagulate it is considered fit to be used as milk. The time that elapses between the birth of the calf and the secretion of normal milk varies, sometimes being from five to seven days and again as long as twenty-one days.

The following analyses made at the Vermont Experient Station will give an idea of the composition of colostrum:

	Total solids. Per cent.	Fat. Per cent.	Sugar. Per cent.	Casein and albumin. Per cent.	Ash. Per cent.
First milking.	19.37	3.86	2.40	11.44	1.67
Second milking	14.33	2.92	3.60	6.49	1.33
Third milking	12.98	2.58	4.16	5.01	1.23
Fourth milking	13.92	3.71	4.28	4.71	1.24
Three weeks after calving	13.52	4.60	5.00	3.34	.58

35. *Constituents of Cow's Milk.*—In a broad way cow's milk is composed of fat, sugar, proteids, mineral matter, and water. Blood, pus, and epithelium may be present under certain conditions. The fat is not a single body but a mixture of various fats (28), which change somewhat in character, depending on the period of lactation and the character of the cow's food. Cotton seed fed to cows makes a hard milk fat; linseed meal makes a soft fat. The fat is suspended in the milk serum in fine globules, the size of which varies with the breed of cows and also in different portions of a milking (36).

There are two carbohydrates in cow's milk, the principal one being lactose, the common milk sugar.

The proteids of cow's milk as far as known are composed of casein (by some authors called caseinogen), albumin, albumoses, peptones, and Storch's mucoid proteid, which has the property of swelling up under the action of alkalies (45).

The mineral matter of milk is not thoroughly understood, but the following analysis by Richmond tells about all that is known of it.

"The ash does not truly represent the mineral con-

stituents of milk. The average composition of the ash of milk is:

	Per cent.
Lime	20.27
Magnesia	2.80
Potash	28.71
Soda	6.67
Phosphoric acid	29.33
Chlorine	14.00
Carbonic acid	.97
Sulphuric acid	Trace.
Ferric oxide, etc.	.40
	103.15
Less O + Cl	3.15
	100.00"

Lecithin found dissolved in the fat, citric acid, urea, and cholesterin are minor constituents of cow's milk. Certain enzymes are also found in milk, but these have practically no importance except in the manufacture of various kinds of cheese. These enzymes are mentioned in another place (32).

36. *Composition of Cow's Milk.*—The composition of cow's milk varies greatly, and it is impossible to give a representative analysis that will do more than show what the average composition of milk would be during a long period if the cows gave the same milk each day and at each milking. This kind of analysis is useful only in showing the amount of food material cows produce during a stated period.

One Cow's Milk.—The milk of individual cows shows great and sudden variations in composition, and it is for this reason that the mixed milk of a herd of cows is better for general use than one cow's milk. While there are great differences in composition between the mixed milks of different herds of cows, there are not apt to be *great*

and sudden variations, and with care the milk can be kept very uniform in composition.

The changes in composition in one cow's milk are caused by various influences, as sudden change of the character of the food, fright, unfamiliar surroundings, and irregular intervals between milkings. *Gradual change* in the character of the food, running from low proteid to high proteid and vice versa, low fat to high fat and vice versa, and high carbohydrates and low proteids cause no perceptible change in the composition of the milk. It is the opinion of all investigators that the quantity and quality of the milk depend on the *cow*, and that there is no method of feeding that will cause a particular cow to change the natural quality and quantity of milk secreted, except for a few days, when there will be a return to the normal of each cow.

The following analyses of individual cow's milk show: (1) The variation in quantity of fat and size of fat globules in different portions of a milking—the solids not fat seem to change little; (2) the variations in composition and yield of milk during a lactation period; and (3) the effect of irregular hours of milking. These analyses are suggestive of changes and conditions affecting the secretion and composition of breast milk.

(1) Fractional Milkings. Boussingault (quoted by Richmond) reports:

	First portion. Per cent.	Second portion. Per cent.	Third portion. Per cent.	Fourth portion. Per cent.	Fifth portion. Per cent.	Sixth portion. Per cent.
Total solids..........	10.47	10.75	10.85	11.23	11.63	12.67
Fat..................	1.70	1.76	2.10	2.54	3.14	4.08
Solids not fat.........	8.77	8.99	8.75	8.69	8.49	8.59

Collier at the New York (Geneva) Experiment Station obtained the following figures:

		Fat. Per cent.	Relative size fat globules.
First Cow—			
First	pint	0.3	36
Second	"	.3	44
Third	"	.4	93
Fourth	"	.7	108
Fifth	"	.7	97
Sixth	"	1.12	133
Seventh	"	1.7	154
Eighth	"	2.2	174
Ninth	"	2.55	114
Tenth	"	3.0	147
Eleventh	"	3.35	190
Twelfth	"	3.9	194
Thirteenth	"	4.95	251
All mixed		1 9	129
Second Cow—			
First	pint	0.5	128
Second	"	1.1	204
Third	"	1.3	178
Fourth	"	1.8	137
Fifth	"	2.4	342
Sixth	"	3.4	221
Seventh	"	4.45	340
Eighth	"	5.0	347
Ninth	"	5.0	270
Tenth	"	6.25	365
All mixed		2.77	218
Third Cow—			
First	pint	1.55	387
Second	"	3.05	367
Third	"	3.30	388
Fourth	"	4.00	476
Fifth	"	4.40	323
Sixth	"	5.00	575
Seventh	"	6.10	565
Eighth	"	6.50	833
Ninth	"	7.00	722
Tenth	"	8.05	725
Eleventh	"	9.40	644
All mixed		6.00	659

(2) Variations in composition and yield during a lactation period, reported by Farrington.

HOLSTEIN COW—278 SAMPLES.

Daily yield in pounds.		Fat—per cent.	
Highest	37.0	Highest	6.6
Lowest	1.7	Lowest	1.5
Average	21.7	72 times below	3.0
		25 " above	4.5
Solids not fats—per cent.			
Highest	10.9	Proteids—per cent.	
Lowest	7.2	Highest	4 11
8 times below	8.0	Lowest	2.64
24 " above	9.0		

SHORT HORN COW—428 SAMPLES—SUDDEN CHANGES NOT COMMON.

Daily yield in pounds—		Fat—per cent.	
Highest	26.5	Highest	7.9
Lowest	3.5	Lowest	2.5
Average	14.4	17 times below	3.0
		38 " above	4.5
Solids not fat—per cent.			
Highest	11.3	Proteids—per cent.	
Lowest	7.2	Highest	3.89
11 times below	8.5	Lowest	2.92
7 " above	10.5		

JERSEY COW—614 SAMPLES—SUDDEN CHANGES COMMON.

Daily yield in pounds—		Fat—per cent.	
Highest	25.5	Highest	12.3
Lowest	1.0	Lowest	2.9
Average	16.4	5 times below	3.5
		25 " above	7.0
Solids not fat—per cent.			
Highest	11.7	Proteids—per cent.	
Lowest	7.6	Highest	5.3
3 times below	8.0	Lowest	2.98
24 " above	10.5		

(3) Unequal Intervals between Milkings. The shorter the intervals between milkings the smaller will be the yield and the richer the milk. Long intervals cause large quantities of poor milk. It is for this reason that generally in summer, morning milk is richer than night milk, and in winter, night milk is richer than morning milk.

Cows are milked the first thing in the morning and the last thing at night by most farmers. In summer the *nights* are about nine hours long, and in winter the *days* have about this same length. The following tests made at the Delaware Experiment Station illustrate these statements.

	Yield. Ounces.	Fat. Per cent.	Total solids. Per cent.
Milking at 7 A.M	154.6	4.63	14.25
" " 7 P.M	151.0	4.74	14.37
" " 8 A.M	184.0	4.36	14.53
" " 5 P.M	112.5	5.32	15.36

	Night milk. Fat—per cent.	Morning milk. Fat—per cent.
July 24th	3.76	4.67
February 5th	4.56	3.53

37. *Curding of Milk.*—The curding of sour milk, so familiar to every one, consists of a precipitation of the casein by the lactic acid developed during the souring process, forming lactate and bilactate of casein. Upon neutralizing the acid with an alkali the casein goes back into its original condition. The curding of milk in the stomach is an entirely different process (**6, 31**). It is brought about by the action of rennet, which clots the casein very much as blood is clotted by the enzyme *thrombase* which exists in the blood. This clotted casein is called paracasein. The milk forms a solid jelly when acted on by rennet, which soon begins to contract, and a greenish-yellow fluid known as *whey* exudes, which contains a small amount of fat, the soluble proteids, the sugars, and part of the mineral matter of the milk. A slightly acid condition of the milk greatly favors the curding or clotting of milk by rennet. When the conditions are right the curd shrinks

rapidly and forms a tough, semi-fibrous mass that contains the fat in its meshes. If this curd is broken into small particles they readily unite again into a solid mass if allowed to remain in contact with each other; but if the particles are agitated for a few moments a skin or membrane forms on each, which prevents their uniting. The casein in this form of curd is changed chemically and cannot be put back into its original form by any known process. The rennet and acid curds are a mixture of paracasein and lactate and bilactate or chloride and bichloride of paracasein, depending on which acid was present.

It is often stated that cow's milk has an acid reaction when it leaves the cow or in its fresh state. Acidity of milk is never estimated directly, but by the use of some color indicator. Milk that is neutral to litmus is usually quite acid to phenolphthalein; but it is thought that this is not true acidity, but the effect of the salts and mucin found in the milk. The acidity of milk that aids the action of rennet is true acidity and is shown by litmus. An interesting proof that the acidity to phenolphthalein is not true acidity has been shown by Babcock, Russell, Vivian, and Hastings. They found that pepsin, which digests proteid only in the presence of acid, would not attack the proteids of milk that was acid to phenolphthalein until 0.2 per cent HCl was added, also that boiled milk would not coagulate with rennet; but it did so at once, as soon as acidified (82).

It is important that the difference between the acid curds and rennet curds of milk should be understood. Much confusion has arisen because this difference was

not considered. Series of tests with acid curds have been used as bases for preparing cow's milk for infant feeding, but as, under physiological or rennet curding, entirely different results are obtained, these teachings, based on acid curding of milk, have been abandoned.

A clear conception of the difference between the acid curding (precipitation of casein) and the rennet curding (clotting of cow's milk) can be quickly obtained by performing the following experiments, preferably in small evaporating dishes:

1st. Dissolve 1 c.c. of hydrochloric acid in 99 c.c. of water. Add this gradually to 60 c.c. of fresh milk that is neutral or only faintly acid to litmus paper until a precipitate forms, and note how many cubic centimetres of the dilute acid were required to precipitate the casein. This is similar to the sour milk curds and is a mixture of mono- and bichloride of casein.

2d. To 60 c.c. of the same milk add *first* 1 or 2 c.c. of a solution of rennet made from the commercial liquid rennet or from the junket tablets sold in all grocery stores—one tablet to 30 c.c. water—and then add the dilute hydrochloric acid until a precipitate forms, and note how many cubic centimetres of the dilute acid were required to cause the precipitate to form. Much less acid will be required than when no rennet is used. Now bring the curded milk to blood heat and the rennet curd will begin to shrink and *after a few minutes* will become tough and fibrous so that it can be handled without breaking. This curd is a mixture of paracasein and chlorides of paracasein.

If this experiment is performed, using 20 c.c. of milk and 40 c.c. of water, the shrinking is more pronounced.

With a little practice, milk diluted ten times with water can be curded with rennet so that all of the curd will unite into one small piece. Without the addition of the dilute acid the curding process takes more time. If the casein is first precipitated by the acid the rennet will not cause it to clot. Occasionally specimens of milk will be met that do not readily form a curd with rennet. Pasteurized and sterilized milk do not readily curd with rennet.

38. *Mixed Milks and Whey.*—Market milk is a mixture of the secretion of many cows, and varies between three and five per cent of fat; but the milk of any particular milkman is quite uniform from day to day. It is useless then to think of average milk, so a number of complete analyses of milks within the normal range will be given. In many of the older analyses of milk the total proteids are called casein; in other analyses the total proteids and the casein have been determined, and the difference between these has been called albumin. In some more recent analyses the proteids other than casein have been determined, but there is as yet no generally accepted method of separating these proteids.

As the relation between the quantity of casein and so-called albumin of milk has been made the basis of a system of infant feeding, some space will be given to this subject.

It has been pretty generally believed and accepted, on the authority of Koenig and Blyth, that there is a quite constant ratio between casein and albumin of cow's milk, there being about five times as much casein as albumin. Van Slyke, in looking over a large number of analyses of normal milks reported by different analysts, found that the ratio between casein and albumin in these analyses

was as high as ten parts of casein to one of albumin, and as low as three parts of casein to one of albumin. He then began a systematic examination of milk to determine the ratio between casein and albumin, if there was one. This test, which is remarkable, extended over a period of several years; and during the first year the milk of fifteen hundred cows in four counties of New York State was used at several cheese factories. The total quantity of milk used was 214,684 pounds, and 106 analyses were made in triplicate to exclude any chance of error. His conclusions then were: "Our results show that the relation of albumin to casein is a very variable one instead of constant, and in no single instance did any sample of the mixed normal milk contain as much as five parts of casein for one of albumin, the highest being 4.9, while the average was 3.76 parts casein for one of albumin."

In the following analyses of Van Slyke, the casein and albumin (total proteids), and casein were determined directly, and the water, albumin, sugar, and ash indirectly. These analyses were made in triplicate both for the milk and the whey, and are exceedingly useful in showing the range of composition of mixed milks that may be met anywhere, and the composition of whey made from a particular milk.

	Water. Per cent.	Total solids. Per cent.	Fat. Per cent.	Casein and albumin. Per cent.	Casein. Per cent.	Difference. Albumin, albumoses, and peptones.	Sugar and ash. Per cent.
Milk	88.40	11.60	3.05	2.64	1.98	0.66	5.91
Whey	93.13	6.87	.28	.69	....	....	5.90
Milk	87.81	12.19	3.10	2.72	2.06	.66	6.37
Whey	92.60	7.40	.33	.71	....	....	6.36
Milk	87.97	12.03	3.30	2.63	2.03	.60	6.10
Whey	92.83	7.17	.36	.71	....	....	6.10

	Water. Per cent.	Total solids. Per cent.	Fat. Per cent.	Casein and albumin. Per cent.	Casein. Per cent.	Difference. Albumin, albumoses, and peptones.	Sugar and ash. Per cent.
Milk........	87.94	12.06	3.35	2.65	1.97	.68	6.06
Whey........	92.82	7.18	.34	.72	....	....	6.12
Milk........	87.52	12.48	3.45	3.20	2.43	.77	5.83
Whey........	92.93	7.07	.23	.88	....	...	5.96
Milk........	87.52	12.48	3.50	3.14	2.47	.67	5.84
Whey........	93.02	6.98	.38	.81	...	...	5.79
Milk	87.80	12.20	3.55	3.09	2.51	.58	5.56
Whey........	93.27	6.73	.40	.81	...	...	5.52
Milk	87.45	12.55	3.60	3.15	2.44	.71	5.80
Whey.......	93.04	6.96	.32	.83	...	...	5.81
Milk	87.38	12.62	3.65	3.15	2.47	.68	5.82
Whey........	93.05	6.95	.30	.86	...	..	5.79
Milk........	87.46	12.54	3.70	3.13	2.49	.64	5.71
Whey........	93.17	6.83	.32	.85	....	....	5.66
Milk........	87.41	12.59	3.75	3.06	2.48	.58	5.78
Whey........	93.18	6.82	.34	.83	...	....	5.65
Milk	87.54	12.46	3.80	3.08	2.46	.62	5.58
Whey........	93.19	6.81	.44	.82	...	....	5.55
Milk	87.34	12.66	3.85	3.18	2.53	.65	5.63
Whey.......	93.16	6.84	.37	.86	....	....	5.61
Milk	87.41	12.59	3.90	3.18	2.56	.62	5.51
Whey........	93.23	6.77	.36	.83	...	....	5.58
Milk	87.29	12.71	3.95	3.22	2.49	.73	5.54
Whey........	93.10	6.90	.34	.88	....	....	5.68
Milk	87.00	13.00	4.00	3.29	2.68	.61	5.71
Whey........	93.04	6.96	.30	.87	....	....	5.79
Milk	86.91	13.09	4.05	3.45	2.77	.68	5.59
Whey........	93.17	6.83	.37	.87	...	..	5.59
Milk	86 92	13.08	4.10	3.36	2.68	.68	5.62
Whey........	93.18	6.82	.35	.89	....	....	5.58
Milk	86.59	13.41	4.15	3.48	2.76	.72	5.78
Whey	93.04	6.96	.35	.91	....	...	5.70
Milk	86.16	13.84	4.20	3.38	2.62	.76	6.26
Whey........	92.50	7.50	.34	.89	....	....	6.27
Milk	86.53	13.47	4.25	3.48	2 75	.73	5.74
Whey........	93.28	6.72	.32	.94	...	....	5.46
Milk	86.61	13.39	4.30	3.44	2.64	.80	5.65
Whey........	92.91	7.09	.31	.90	....	....	5.88
Milk	86.31	13.69	4.35	3.59	2.90	.69	5.75
Whey........	93.00	7.09	.35	.94	....	....	5.71
Milk	86.54	13.46	4.40	3.46	2.71	.75	5.60
Whey........	92.96	7.04	.40	.88	....	....	5.76

	Water. Per cent.	Total solids. Per cent.	Fat. Per cent.	Casein and albumin. Per cent.	Casein. Per cent.	Difference. Albumin, albumoses, and peptones.	Sugar and ash. Per cent.
Milk	85.90	14.10	4.55	3.62	3.06	.56	5.93
Whey........	92.94	7.06	.34	.97	....	...	5.75
Milk	85.18	14.82	4.85	3.93	3.13	.80	6.04
Whey........	92.50	7.50	.31	1.01	..	...	6.18
Milk	85.37	14.63	5.00	3.99	3.14	.85	5.64
Whey........	92.62	7.38	.30	1.03	...	....	6.04
Milk	85.13	14.87	5.10	4.00	3.18	.82	5.77
Whey........	92.56	7.44	.34	1.04	....	....	6.06
Milk	85.06	14.94	5.25	3.86	3.10	.76	5.83
Whey........	92.74	7.26	.36	1.04	...	....	5.86

In a series of analyses made in another year, the proteids were further separated and the range for the year was: Total solids, 12.29 to 13.39 per cent; fat, 3.40 to 4.10 per cent; casein, 2.19 to 2.26 per cent; albumin, 0.28 to 0.38 per cent; albumoses, 0.30 to 0.50 per cent.

Babcock and Russell in 1897 published the following analyses of the proteids of many samples of cow's milk:

Total nitrogen. Per cent.	Casein nitrogen. Per cent.	Albumose and peptone nitrogen. Per cent.		Total proteids. Per cent.	Casein. Per cent.	Albumoses and peptone. Per cent.	Albumin by difference. Per cent.
0.46	0.34	0.08		2.87	2.12	0.50	0.25
.51	.43	.04		3.18	2.68	.25	.25
.52	.40	.04		3.25	2.50	.31	.50
.53	.39	.05		3.31	2.44	.31	.56
.55	.46	.04	× 6.25 = (by author)	3.43	2.87	.25	.31
.55	.46	.05		3.43	2.87	.31	.25
.56	.45	.04		3.50	2.81	.25	.44
.57	.43	.05		3.56	2.68	.31	.57
.58	.47	.07		3.62	2.94	.43	.25
.58	.41	.08		3.62	2.56	.50	.55
.59	.44	.04		3.68	2.75	.25	.68
.60	.46	.04		3.75	2.87	.25	.63
.72	.56	.70		4.50	3.50	.44	.56

The following analyses made by a professional chemist of high grade Jersey milk (Briarcliff Farms) will show the relative proportions of fat and proteids in very rich milk:

	Fat.	Proteids (N × 6.25).	Milk Sugar (by difference).	Ash.
April, 1900	5.14	3.48	4.88	0.75
May, 1900	5.22	3.58	4.84	.73
June, 1900	5.10	3.59	4.85	.72
July, 1900	5.00	3.54	4.84	.75
August, 1900	5.00	3.58	4.79	.74
September, 1900	5.39	3.75	4.84	.75
October, 1900	5.23	3.73	4.75	.75
November, 1900	5.35	3.82	4.86	.75
December, 1900	5.20	3.77	4.79	.76
January, 1901	5.36	3.76	4.83	.74
February, 1901	5.24	3.67	4.87	.75
March, 1901	5.19	3.57	4.90	.73
April, 1901	5.13	3.66	4.89	.75
May, 1901	5.12	3.54	4.84	.75
June, 1901	5.38	3.59	4.91	.76
July, 1901	5.29	3.50	4.71	.73
August, 1901	5.28	3.54	4.78	.74
September, 1901	5.27	3.56	4.77	.74
October, 1901	5.48	3.87	4.89	.74
November, 1901	5.32	3.87	4.86	.76
December, 1901	5.34	3.85	4.81	.77
January, 1902	5.35	3.82	4.89	.76
February, 1902	5.38	3.72	4.88	.75
March, 1902	5.37	3.57	4.84	.74
April, 1902	5.18	3.53	4.84	.73
May, 1902	5.40	3.67	4.92	.73
June, 1902	5.35	3.59	4.77	.74
July, 1902	5.36	3.48	4.84	.72
August, 1902	5.30	3.66	4.75	.75
September, 1902	5.35	3.65	4.81	.72
October, 1902	5.38	3.78	4.83	.76
November, 1902	5.69	3.78	4.83	.74
December, 1902	5.89	3.95	4.82	.77
January, 1903	5.88	3.81	4.88	.76
February, 1903	5.82	3.81	4.82	.75
March, 1903	5.80	3.76	4.86	.73
April, 1903	5.83	3.56	4.85	.73
May, 1903	5.72	3.65	4.91	.73
June, 1903	5.55	3.56	4.87	.74
July, 1903	5.20	3.45	4.64	.75
August, 1903	5.34	3.47	4.92	.72
September, 1903	5.31	3.48	4.81	.73
October, 1903	5.38	3.55	4.74	.75
November, 1903	5.20	3.75	4.80	.74
December, 1903	5.69	3.84	4.86	.75
January, 1904	5.72	3.81	4.71	.76
February, 1904	5.57	3.75	4.87	.76

39. *Cream.*—The fat globules of milk being much

lighter than the other ingredients of the milk have a tendency to rise to the surface if the milk is allowed to remain undisturbed for any length of time. The separation of the fat from the other ingredients of the milk is not complete, so cream is a mixture of milk elements in which fat greatly predominates.

40. *Cream Separating.*—There are three methods of separating cream from milk. (1st) The shallow-pan system in which the milk is poured into wide, shallow pans; (2d) the deep-setting system, in which the milk is put into tall, narrow vessels, and allowed to stand; and (3d) the centrifugal process in which the milk is run through a bowl which revolves at a high rate of speed.

41. *Gravity Cream.*—Cream that is allowed to rise naturally and is then skimmed by hand is called gravity cream. The separation of cream in the shallow-pan system is not very complete, and this system is not used much in producing cream for market.

Strange to say, if milk is put into *tall* narrow vessels and placed in cold water at 45° F., the cream rises quickly and completely, the skim milk often containing not over 0.2 to 0.4 per cent of fat. This system is well illustrated by bottled milk, on which the layer of cream can usually be plainly seen.

42. *Time Required for Cream to Rise.*—If milk is placed in cans or bottles *immediately* after milking, before it has had time to cool, the separation of cream is rapid. At the end of four hours nearly all the cream that will rise will have risen; but if the milk has been stirred and cooled before it is set for the cream to rise, the separation will take many hours longer and will not then be as complete (132).

Other conditions affecting the separation of cream are the size of the fat globules, the passing of milk through a centrifugal machine as is sometimes done to remove

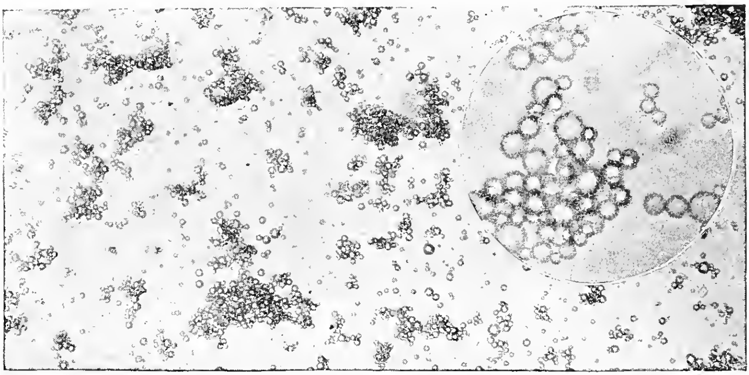


FIG. 16.—Microscopic Appearance of Normal Milk. (Babcock and Russell.) Fat globules in clusters.

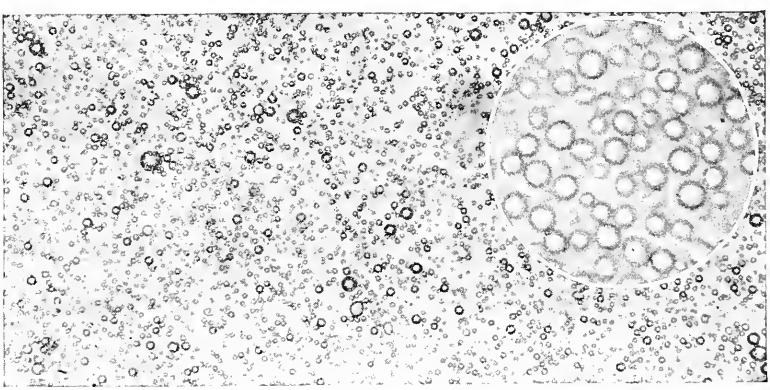


FIG. 17.—Microscopic Appearance of Centrifuged, or Heated Milk. (Babcock and Russell.) Fat globules not in clusters.

dirt, and heating the milk. The smaller the fat globules the longer time is required for the cream to rise. In the milk of certain breeds of cows the fat globules are very small; such milk does not cream well. In rich milks,

containing over four and one-half per cent of fat, the fat globules are larger and creaming is rapid and complete (36). Passing milk through a centrifugal machine breaks up the natural arrangement of the fat globules; and gravity cream from such milk separates slowly and incompletely, is very thin and limpid, and apt to deceive in richness one who has not tested it. Such cream, containing over twenty per cent of fat, is often apparently not thicker than rich milk. Heating milk also prevents its creaming well.

43. *Centrifugal Cream.*—The first centrifugal cream separators were simple buckets of milk which were whirled until the cream rose, when it was skimmed by hand. Later a circular bowl was devised, which when revolved three thousand to five thousand times a minute caused a rapid separation of cream. The milk arranges itself into several layers. The dirt and heavy particles, such as epithelium and manure, are thrown against the side of the bowl; next comes the skim milk, and then the cream which is lightest is nearest the centre of the bowl. A clear idea of the state of the milk in a separator bowl can be had by imagining a quart bottle of milk on which the cream has risen being laid on its side without the arrangement of the cream being disturbed. The bottom of the bottle with its sediment would correspond to the side of the bowl and the mouth of the bottle to the centre of the bowl. Now imagine a small stream flowing from the layer of cream near the mouth of the bottle and another from the skim milk near the bottom of the bottle, with the bottle kept filled all the time by a fresh supply stream of milk that separated as soon as it entered the bottle into the layers of dirt, skim milk, and cream, and the centrifugal cream separator will be understood.

The illustration shows a simple style of separator bowl in operation.

The length of time the milk remains in the bowl of the separator can be regulated and the cream made richer

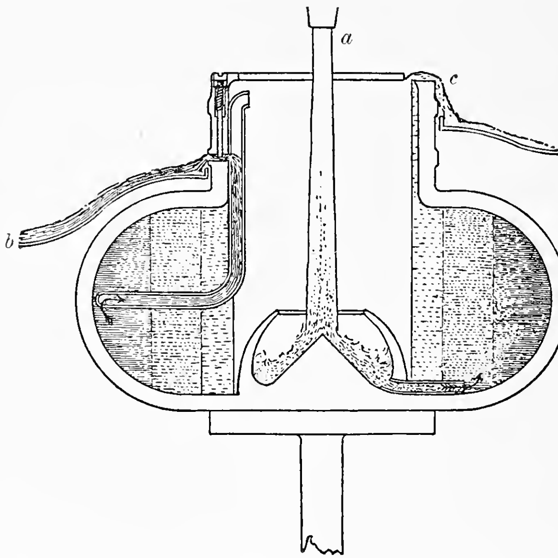


FIG. 18.—Centrifugal Cream Separator. (Wing.) *a*, Inflowing milk; *b*, outflowing skimmed milk; *c*, outflowing cream.

or poorer in fat accordingly. The shorter the time the milk is in the bowl the poorer the cream is in fat.

44. *Separator Slime.*—After a quantity of milk has been passed through a separator there is found sticking to the inside of the bowl what is known as separator slime. Its composition is variable, but it generally consists of epithelium, mucus, pus, blood, dirt, manure, hair; and if the milk is slightly sour, of quantities of precipitated casein. There is always more or less of this separator slime, even if the best and cleanest milk is used. It is not necessarily filth, although when obtained from dirty milk it contains much filth.

45. *Difference between Gravity and Centrifugal Cream.*—When milk leaves the cow the fat globules are free; but shortly after milking they form themselves into little groups, supposedly under the action of a substance similar to fibrin. When milk is passed through a separator or is heated for that matter, this arrangement of the fat globules is broken up (43). There is also a separation of the proteids. To quote Babcock and Russell: "A chemical analysis of fresh separator creams showed that from eighteen to thirty-eight per cent of the total protein was present in the form of albumoses and peptones," while they found, on an average, that in fresh whole milk 9.69 per cent of the protein was albumoses and peptones. Hence there is a great difference, both physical and chemical, between gravity and centrifugal creams; and, in the author's opinion, gravity cream from bottled milk is to be preferred for use in infant feeding on the principle that the less the milk is manipulated and the ingredients are separated, the better.

In butter-making this separation of proteids and change in form of the emulsion of the fats in centrifugal cream is not a disadvantage, for butter can be made from centrifugal cream without the "ripening" or partial souring that gravity cream must undergo before butter can be made from it. For many commercial purposes, however, centrifugal or heated (Pasteurized) creams cannot be used. Charlotte russe and ice-cream makers and cooks insist on having gravity creams because they will "whip," while centrifugal or Pasteurized creams will not "whip."

Cream Thickeners.—To overcome the objections thus inherent in centrifugal cream, Babcock and Russell in-

vented a process of giving "body" to creams, which consists of adding a syrup of lime, which they call "viscogen," to the centrifugal or Pasteurized creams. Syrup of lime can be had at any drug store and contains six and one-half per cent of lime. A few drops of this syrup of lime will cause cream or milk to become thick and viscid, its action being on the mucoid proteid (35) of the milk—the distinctive property of mucin being that of forming mucilaginous, stringy solutions when acted upon by a trace of alkali. Any one having much to do with milk or cream should try adding syrup of lime to both and should also taste them when thickened. The taste is distinctive but not unpleasant.

Another method of thickening cream consists of adding solutions of gelatin. Such thickeners are sold by dairy supply houses under different names (see cream, albuminoid) (63).

46. *Condensed Milk.*—There are two distinct kinds of condensed milk which are widely used—fresh condensed milk and canned condensed milk. Milk is first heated up to near boiling point and a large portion of water then removed by boiling at a low temperature in vacuum pans. The condensed milk is then filled into bottles or cans if it is to be sold in its fresh state; or cane sugar is added, and it is then filled into tin cans and hermetically sealed if it is to be kept for any length of time.

During the past three or four years there has been a greatly increased sale of unsweetened condensed milk put up in sealed tin cans. These milks are limpid, yellow in color, and have a strong "cooked" taste. They are sold under the name of "Evaporated Creams," a misleading

term, as many brands of condensed milk contain more fat than these so-called creams. The labels on the cans of evaporated cream usually state that it is simply pure milk thoroughly sterilized and reduced to the *consistency* of cream. These evaporated creams are apt to become putrid when diluted and exposed to the air, and for this reason are being put up in small cans, the contents of which will be used up quickly.

There has recently been devised a process of condensing milk without the aid of heat. The cream is first removed by a separator (43) and the skim milk is then frozen. As fast as crystals of ice appear the milk is stirred and in time becomes like slushy snow. The water in crystallizing throws out the proteids, sugars, and mineral matter of the milk as a syrupy mass. The frozen milk is then put in a centrifugal machine, such as is used in driving out the molasses from raw sugar, and the syrupy mass of proteids, sugar, and mineral matter is thus separated from the ice crystals. The cream is now mixed with the syrupy mass and the mixture, when diluted with three parts of water, equals the original milk.

As yet this condensed milk is not on the market, but if it becomes possible to render it sterile without the use of heat, so that it can be kept indefinitely, it is likely to become a very useful article of food.

The following analyses of condensed milks furnished the author by Major Alvord, Chief of Dairy Division, United States Department of Agriculture, are of milks bought in San Francisco. Only four States, Illinois, New York, Ohio, and Oregon, have laws (79) relating to the quality of condensed milk, so any kind of condensed

milk can be sold in the other States. These analyses do not represent all the brands in the market by any means, but they do show the range in quality likely to be met with. Any of the evaporated creams or unsweetened condensed milks may be tested in a few moments by the fat and specific gravity test (75) when diluted with two parts of water, quite accurate results being obtained. Sweetened condensed milks cannot be easily tested in this way, as the excess of sugar interferes with the fat test.

Unsweetened Condensed Milk.

Whole Milk (so-called Evaporated Creams).

Water.	Fat.	Proteids.	Milk sugar.	Solids not fat.	Cane sugar.	Ash.	Brand.
68.27	10.10	7.36	11.03	....	....	1.85	Ideal.
69.17	10.40	8.01	....	20.43	....	1.79	California Poppy.
69.58	9.02	7.77	10.62	....	....	1.80	Highland.
72.78	9.37	7.66	....	17.85	....	1.61	Lily.
72.92	8.34	6.00	....	18.74	....	1.71	Red carnation.

Evidently Skimmed or Partly Skimmed Milk.

74.29	1.80	8.97	....	23.91	....	2.39	Monarch.
80.58	5.70	7.02	....	13.72	....	1.69	"99."

Sweetened Condensed Milk.

Whole Milk.

Water.	Fat.	Proteids.	Milk sugar.	Cane sugar.	Ash.	Brand.
23.70	10.82	8.54	14.17	39.85	2.13	Milk Maid.
25.25	10.62	7.90	12.53	40.56	1.84	Nestlé's.
26.03	8.54	7.17	12.45	41.82	1.87	Gold Lines.
27.52	8.81	7.48	12.77	41.06	1.63	Eagle Falcon.
28.41	8.44	7.23	11.69	41.52	1.80	Eagle.

SWEETENED CONDENSED MILK—(*Continued*).

Evidently Skimmed or Partly Skimmed Milk.

Water.	Fat.	Proteids.	Milk Sugar.	Cane Sugar.	Ash.	Brand.
25.68	0.71	10.35.	16.85	43.09	2.48	Cowslip.
25.88	0.96	10.64	27.38	34.07	2.56	Snake.
28.48	0.60	7.90	18.76	41.77	2.04	Farm.
29.67	2.47	10.45	19.05	36.00	2.29	Pearl.

CONDENSED CREAMS.

Water.	Fat.	Proteids.	Solids not fat.	Ash.	Brand.
59.60	34.19	....	6.21	0.53	Dahl's Gold Medal.
65.26	28.26	....	6.48	0.56	Empress.
69.84	23.83	...	6.33	0.67	California.

CHAPTER XI.

BACTERIOLOGY OF MILK.

47. PRACTICALLY all of the changes that take place in milk that is kept for any length of time are the result of bacterial growth. The mere presence of bacteria in milk, even in large numbers, however, does not necessarily mean that the milk is harmful and unfit for use as food. A great deal of misapprehension exists on this point, and it can be removed only by a better knowledge of the function and properties of bacteria. To many, bacteria suggest disease, and it has been thought that all bacteria should be destroyed; but now it is known that their indiscriminate destruction would prove to be a great calamity, as bacteria are absolutely essential to the life of plants and animals, the function of most bacteria being to reduce to gases, and soil, which is a mixture of earth and decomposing organic matter, all lifeless organic matter, which then serves as food for plants, and these in their turn nourish all animal life. Bacteria serve other useful and valuable purposes. The delicate flavor of June butter is caused by bacterial action, and the manufacture of cheese is largely, if not wholly, dependent on the growth of bacteria in milk. It is true that disease is caused by some kinds of bacteria, but all bacteria should not be condemned and destroyed, even if this could be done, because a few species cause disease.

As bacteria are everywhere present and are sure to be found in milk, a knowledge of their nature and of the conditions under which they gain access to the milk and cause it to change or become harmful is essential.

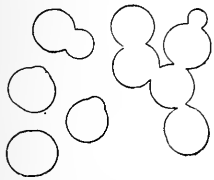


Fig. 19.—Showing Budding of Yeast. (Conn.)

48. *Bacteria.*—Bacteria are microscopic, unicellular, colorless plants, belonging to the class called fungi. They are closely related to the yeasts, but are smaller and also differ from the yeasts in their methods of reproduction. Yeasts multiply by budding, while bacteria multiply by two different methods: 1st. By fission, in which the cell divides through the centre, producing another full-fledged bacterium. 2d. By sporulation, in which spores are formed in the interior of the cell, which breaks up and sets them free. These spores when placed in favorable surroundings germinate and become active bacteria.

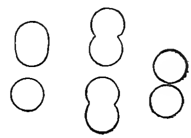


Fig. 20.—Showing Fission of Bacteria. (Conn.)

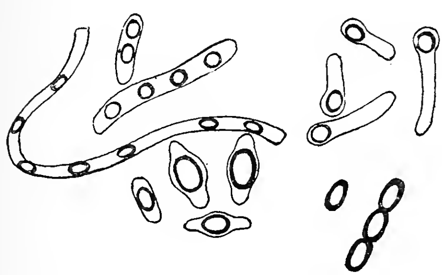


Fig. 21.—Showing Formation of Spores. (Conn.)

Not all species of bacteria are spore-bearing, and this fact has great importance in the preservation of milk and food; for while *active* bacteria are almost without exception easily destroyed by a moderate degree of heat, spores in water or milk are not destroyed by boiling. They may be dried and kept for months or years, and then

when placed under favorable conditions will germinate and develop into active bacteria. Many of the harmful changes in milk are caused by spore-bearing bacteria.

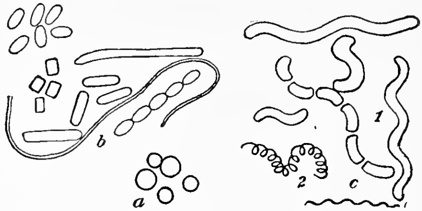


FIG. 22.—*a*, Spheres; *b*, rods; *c*, spirals. (Conn.)

Classification of Bacteria.—Bacteria are divided according to their *form* into three groups:

1. Spherical bacteria—coccus.
2. Rod-shaped bacteria—bacillus and bacterium.
3. Spiral bacteria—spirillum.

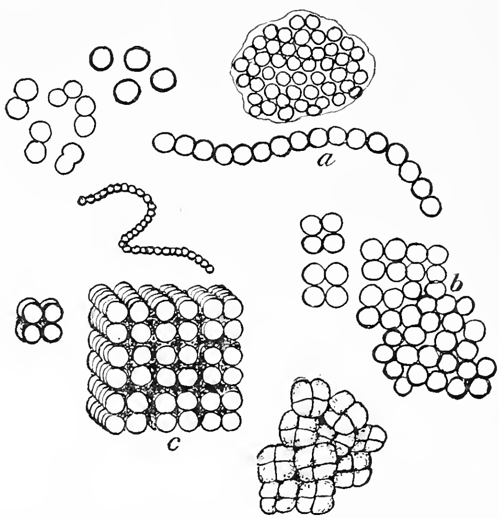


FIG. 23.—*a*, Streptococcus; *b*, micrococcus; *c*, sarcina. (Conn.)

Spherical bacteria are further classified according to the way in which they group themselves during the proc-

ess of division, as streptococcus, in chains; micrococcus, in irregular masses, and sarcina, solid masses in groups of four.

49. Bacteria that grow best in the presence of oxygen or air are called *aerobes;* those that grow best in the absence of oxygen or air are called *anaerobes.* Bacteria which will grow only under one of these conditions are called *obligate* aerobes or anaerobes, while those species that will grow either in the presence or absence of oxygen are called *facultative* aerobes or anaerobes. The greater number of species of bacteria attack and live upon lifeless organic matter and are called *saprophytes;* those species that attack living matter are called *parasites.*

50. *Rate of Growth of Bacteria.*—Bacteria increase in numbers at a prodigious rate. If nothing interfered, in twenty-four hours a single bacterium would produce about seventeen million others. This rate of increase is not met with in practice; but, according to Conn, a specimen of milk containing 153,000 bacteria to the cubic inch contained twenty-four hours later 85,000,000, and a sample of fresh cream, containing 44,000 bacteria to the cubic centimetre, contained 1,300,000,000 when sour enough to churn. The rapidity of increase depends largely on the temperature. Below 45° F. there is comparatively little growth of bacteria; but as the temperature approaches 100° F., the rate of growth increases rapidly.

51. *Food of Bacteria.*—Most bacteria must have a food supply of nitrogenous matter (proteid), carbohydrates (sugar, starch, or cellulose), mineral matter, and water. Furthermore, their food must be in a soluble form so that it can pass through the cell wall of the bacteria and be

not too concentrated. Bacteria cannot grow in substances as thick as syrup. Bacteria that can attack insoluble matter secrete enzymes that digest or convert the insoluble food material into assimilable forms. Thus in milk some species of bacteria will secrete rennet that will curdle the casein of milk, and trypsin that will dissolve or peptonize it. Other bacteria also secrete enzymes that will digest or decompose starch, sugar, cellulose, fat, urea, and other substances.

52. *Souring of Milk.*—As every one knows, the most common change in milk is souring. Milk sours because several species of bacteria attack the sugar of the milk and convert it into lactic acid, which throws the casein out of solution (37). These bacteria may be classed as harmless bacteria, for sour milk is a wholesome article of food and is used in cooking. Before baking powder became so common, sour milk was used with baking soda to make cake and biscuit rise.

It is popularly believed that thunder causes milk to sour, but it has been found that the thunder or electricity of the air has nothing to do with the souring of the milk, but that the atmospheric conditions during a thunder storm are favorable to the growth of lactic-acid bacteria.

Fresh milk always contains several species of bacteria, and if the milk is warm enough they commence to grow at once. The conditions in the milk are generally most favorable for the growth of the species that attack the sugar and produce lactic acid; and if there are any of these bacteria present, as is generally but not always the case, they soon outstrip the other species and kill them

off; hence after a few hours an examination of the milk will often show ninety-nine per cent of the bacteria in the milk to be of the souring variety. When bacteria that cause souring are not present, the other species which attack the fat and proteids of the milk grow and produce rancidity of fat and many changes in the proteids.

53. *Peptonizing Bacteria in Milk.*—When the proteids of milk are attacked by bacteria, they may be first curdled by rennet and then peptonized by trypsin, both secreted by bacteria, or the proteids may be peptonized without first being curdled. Such milk does not sour, but acquires a bitter taste. Bacteria that produce these changes are normally present in milk, but are usually held in check by the souring species; sometimes, however, poisonous products are produced by bacterial action on proteids of milk.

54. *Decomposition of Proteids.*—The decomposition of proteid matter is brought about chiefly by the action of *decomposition bacteria.* When the process of decomposition is caused by aerobic bacteria in the presence of an abundance of air, it is called *decay* and the proteid matter is reduced to simple harmless forms; but, when the decomposition is caused by facultative aerobic or anaerobic bacteria in the absence of an abundance of air, the process is called *putrefaction.* Here the proteid matter is not completely reduced to simple harmless forms; foul-smelling gases are evolved and oftentimes substances that are intensely poisonous are also produced. These poisons may be secretions or excretions of the putrefactive bacteria, or partially reduced proteid matter. Under the action of aerobic bacteria, in the presence of plenty of air,

these gases and poisons are destroyed. The process involved in the decay or putrefaction of proteid matter is not understood. Putrefactive bacteria are present everywhere, but particularly in rich soil and in manure. A gram of rich soil may contain 100,000,000, and a gram of fresh cow's manure as many as 375,000,000 bacteria, most of which will cause decomposition in proteid matter. This fact suggests the importance of keeping cows and stables clean.

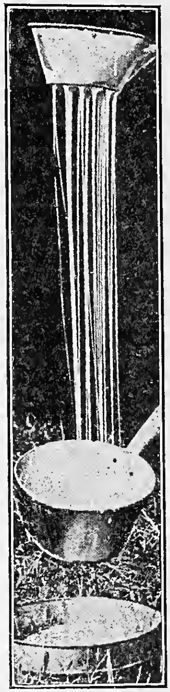


FIG. 24.—Slimy Milk. (Russell.)

Other Bacterial Changes in Milk.—Slimy milk is caused by bacteria found in water, and "gassy" milk by bacteria found particularly in manure particles. Soapy, blue, red, and yellow milks are also the result of bacterial action, but are not common (see Fig. 85).

The bacterial changes of milk may be summed up as souring, peptonizing, putrefactive, and the development of odors, bitter taste, sliminess, soapiness, colors, and gases.

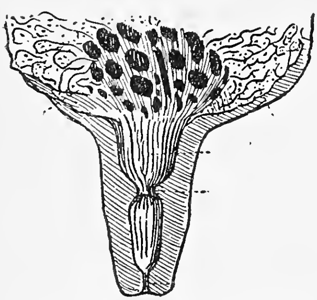


FIG. 25.—Udder and Teat. (Russell.)

Bacterial Diseases Transmitted by Milk.—Typhoid fever is easily transmitted by infected milk. Outbreaks of diphtheria and scarlet fever have been traced to milk supplies, and tuberculosis *may*

possibly but not necessarily be caused by milk containing tubercle bacilli (see Chapter XV.).

How Bacteria Get into Milk and Increase in Numbers.

55. *From the Cow's Udder.*—Just inside the cow's teat is a small cavity that always contains a small quantity of milk. During the intervals between milkings bacteria from the air lodge on the moist teat and make their way into this cavity where they grow. To quote Russell: "As a rule the number of different species found in the fore milk is usually small, not more than one or two forms being present at any time. As to the character of these forms data are conflicting. Harrison reports finding peptonizing bacteria in some, and Marshall states that organisms are found that resist pasteurizing. . . . Bolley in thirty experiments found twelve out of sixteen species to belong to the lactic-acid class. . . . If the fore milk is received into a separate vessel and kept protected from the air, it will be generally noted that it sours more rapidly than the remainder of the milk." In the report of a series of bacterial examinations of milk, D. H. Bergy (Penn. Dept. Agr. Rept., 1900) states: "Milk taken directly from the

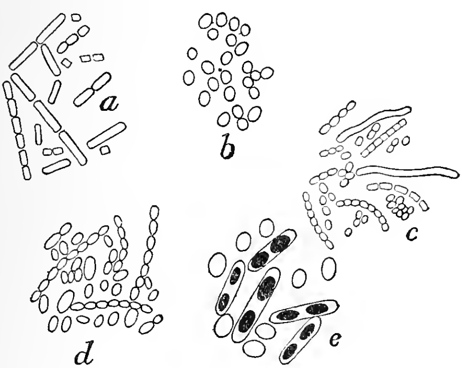


Fig. 26.—Bacteria from Cream. (Conn.) *c* and *d* produce good butter.

udder in the ordinary way and collected in sterile test tubes was always found to contain bacteria of the group streptococci. The number in the first milk drawn was usually greater than [in] the latter portion." Streptococci are usually looked upon by physicians as dangerous bacteria, but it has been found that good butter flavor is produced by some species of streptococci (Fig. 26).

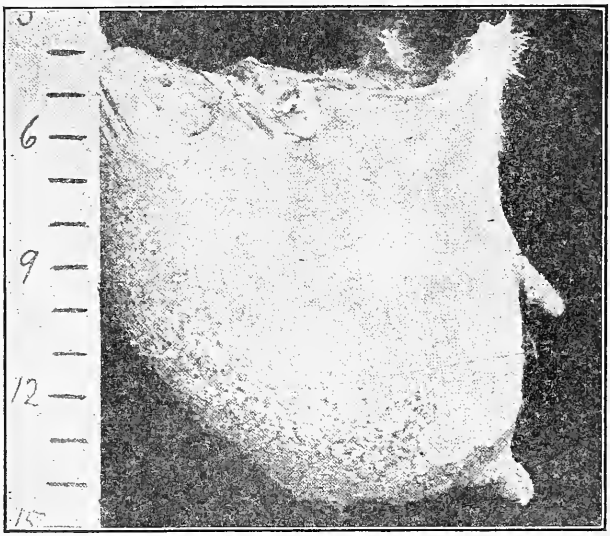


FIG. 27.—Tuberculous Udder. (Russell.)

If the first few jets from each teat are thrown away, the remaining portion of the milking will be quite free from bacteria, provided the cow has no disease of the udder. No milk from a diseased udder should be used as food. Tuberculous udders always secrete milk containing tubercle bacilli, and although there is some doubt about bovine tuberculosis infecting human beings through milk, no risk should be taken. When a cow's udder is tuber-

culous, it is time to stop the use of her milk, whatever may be said of the safety of the milk from cows that simply react to the tuberculin test.*

56. *From the Cow's Body.*—If the cow's body is not kept clean, more or less dirt is bound to be loosened and to fall into the milk pail, along with some hairs, during the process of milking. On a single cow's hair several hundred bacteria have been counted, and, as previously stated, soil and cow's manure, which is the dirt usually found on the cow's body, contains millions of bacteria per gram (54). If the cow has been wading in slimy, stagnant water, the scum from this water dries on the cow's body and some of it will get into the milk; this dried scum is particularly injurious to milk. The bacteria that get into milk with filth are, as a class, the ones that cause the most damage to milk as a food, for many of these species decompose or putrefy the proteids of the milk. They can be kept out of the milk by keeping the cows clean.

Example †: Milk from four *dirty* cows in a clean barn with clean milkers gave an average of ninety thousand bacteria to the cubic centimetre. Milk from four other cows of the same herd, carefully *cleaned* and milked by the same man, gave an average of only two thousand.

57. *From Dust.* — Stable dust contains enormous numbers of bacteria, and if the cows are eating dry hay, or if the milker's clothes are dusty, the milk will

* This test consists of injecting into an animal certain products derived from tubercle bacilli. If the animal is tuberculous they cause a rise of temperature.

† Report of the summer work of the Milk Commission of the Medical Society of the County of New York. (Bacterial examinations made by Dr. Sarah Belcher.)

receive a great many bacteria with the dust that is sure to settle into the milk pail. Dust can be kept out of milk by wiping the cow with a damp cloth and by sprinkling the stable.

Example*: Milk from each of twelve cows in a stable showed low bacterial count except from one which stood next to a pile of dry feed; her milk contained one million bacteria to the cubic centimetre.

58. *From the Milker.*—If the milker's hands are chapped or not clean, or if he is diseased, or is nursing a person

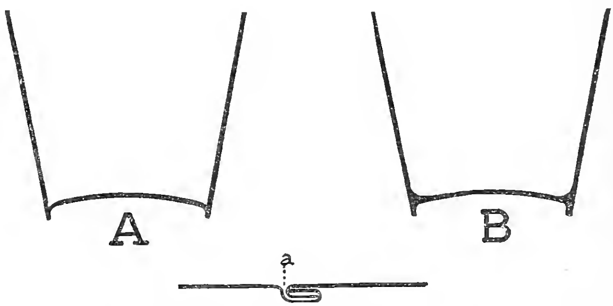


FIG. 28.—*A*, *a*, Improper joints in dairy utensils. *B*, Proper joints closed with solder. (After Russell.)

suffering from some infectious disease, the milk is more than likely to be infected by him. It is in this way that typhoid fever, scarlet fever, diphtheria, and infectious disease germs find their way into milk. Milkers should wear white duck suits or blue overalls that are kept clean by frequent washing.

59. *From Dairy Utensils.*—Any part of a milk pail, vat, cooler, can, bottle, or bottle filler that cannot be kept perfectly clean, always contains many bacteria that will infect any milk they may come in contact with, and for

* See last note on page 95.

this reason all dairy utensils should have perfectly tight smooth seams and joints; even then it is almost impossible to keep the best-made utensils free from bacteria. Washing utensils with ordinary well water or brook water may infect the milk with typhoid germs; they should be washed with boiling water and steamed if possible.

Example*: With ordinary milk pail and strainer the bacterial count was eighty thousand; with sterilized pail and strainer the same day, in the same barn, and with the same cows five thousand bacteria to the cubic centimetre were counted.

60. *By Growth.*—When the milk leaves the cow it is at a temperature of nearly 100° F., which is the ideal temperature for rapid growth of bacteria. If the milk is allowed

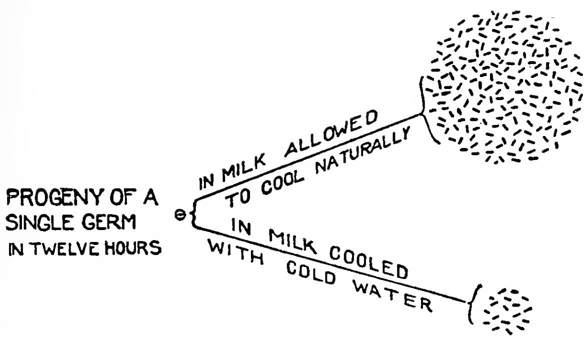


FIG. 29.—Showing the Effect of Cooling Milk on the Growth of Bacteria. (Russell.)

to stand, the bacteria grow rapidly, and in a short time each bacterium will produce hundreds of others. This increase in numbers by growth may easily be prevented by: (1) promptly cooling the milk to below 45° F., and keeping it cool; (2) by heating the milk to destroy the

* See last note on page 95.

bacteria; or (3) by the addition of chemical preservatives. The following figures of Cnopf and Escherich, quoted by Russell, are highly instructive, as is also the illustration by Russell.

RATE OF GROWTH OF SINGLE GERM.

	Two hours.	Three hours.	Four hours.	Five hours.	Six hours.
54° F	4	6	8	26	435
97° F	23	60	215	1,830	3,800

Bacterial Count of Milk.—From the foregoing it will be seen that bacteria originally get into milk principally through lack of cleanliness about the dairy, also that no matter how few bacteria were present in the milk originally, it will soon contain enormous numbers if allowed to stand for any length of time at anywhere near body temperature. Therefore, counting the numbers of bacteria in natural milk—that is, milk that has not been heated to kill the bacteria or to which chemical preservatives have been added—is a valuable way of telling under what conditions it has been produced and kept. Milk produced in dirty surroundings will always contain large numbers of bacteria, while milk produced where cleanliness is the rule will contain few bacteria. If the milk is properly cooled and kept cool there will be but a slight increase in the numbers of the bacteria in the milk after milking. Therefore it is safe to say that natural milk containing few bacteria came from a clean dairy and that the milk was kept cool; and that natural milk containing large numbers of bacteria came from a dirty dairy, or was not kept cool if from a clean dairy, or that the dairy was dirty and the milk was also not cooled. Low bacterial count in natural milk means that the milk has been produced under clean

conditions, and that little or no change has taken place in it.

As all milk contains a certain number of bacteria, what is to be desired is a knowledge of what species of bacteria cause sickness and where they come from. Such information can be obtained only by much patient work on milk that has actually caused sickness.

In the section on testing milk (p. 148) will be found a chapter by Prof. H. W. Conn, on the bacteriological examination of milk. The great experience of Professor Conn and his many bacterial discoveries regarding milk make his methods of work of great value, and suggestive to workers not familiar with bacterial studies in milk.

CHAPTER XII.

PRESERVATION OF MILK.

In the preceding chapter (60) it was shown that the bacterial development and changes in milk could be prevented (1) by heating to kill the bacteria; (2) by the addition of certain chemicals; and (3) by keeping the milk at temperatures below 45° F., when bacteria do not grow to any extent. On these three principles all methods of milk preservation are based.

61. *Sterilization and Pasteurization.*—Before the cause of the changes that take place in milk was discovered, it was known that scalding or boiling would prevent it from souring. With a knowledge of bacteria and their *supposed always* dangerous properties, came the belief that all milk for infants and possibly for adults should be sterilized—heated to 212° F., so as to kill all bacteria present. Such milk had a "cooked" taste, and its physical and chemical properties were changed (42), and few adults would use it. It was then discovered that at temperatures ranging from 140° to 175° F., most of the bacteria found in milk were destroyed if the milk was properly handled during heating. This process is called pasteurization after Pasteur, who first used it to any extent. Russell states that in some milk pasteurized on a commercial scale at the Wisconsin Dairy School, there were less than one thousand bacteria per cubic centimetre in

half of the samples, while the average of twenty-five samples was 6,140 per cubic centimetre. Even at these low temperatures the taste of the milk is slightly changed and the natural arrangement of the fat emulsion is destroyed (42).

62. In some cities milk dealers pasteurize their milk before delivering it to their customers, but such milk may in the end prove more injurious than natural milk. If the milk was originally dirty or contained as much as .2 per cent acid produced by the growth of bacteria, it will not pasteurize satisfactorily, as many spore-bearing bacteria will be present. The heat destroys the active bacteria, most of which produce souring, but spores are not destroyed (48).

Pasteurized milk will seldom sour, but unless the milk is cooled the spores will germinate and produce bacteria that will attack the proteids of the milk, and it is the products of some of these bacteria that are thought to be poisonous. These spores cannot grow in sweetened condensed milk (46), because it is too concentrated (51).

A very convincing demonstration of the presence and effect of spores in milk is as follows:

Take four test-tubes of fresh milk; to one add a little dried cow's manure; to another a little dust from a city street. Boil both of these and also a tube of the natural milk. Plug all four with cotton and set them in a cup of tepid water. The unboiled milk will probably sour in a few hours. The plain boiled milk *may* not change for days, while that with the cow's manure or dust will probably curdle without the production of acid in ten or twelve hours, owing to the development of spores into bacteria

that attack the proteids of the milk. For this reason boiled milk sometimes gives off an extremely offensive odor if kept for any length of time. If milk is to be made absolutely sterile it must be heated several times, with intervals between, to allow the spores to germinate so that they can be killed by subsequent heatings.

It will be seen that neither pasteurization nor ordinary sterilization will enable milk to be kept for any great length of time without cooling, so these processes simply allow of a little more *carelessness* in the handling of milk during and after milking, and put off for a few hours the changing of the milk. In Europe pasteurization is commonly used, for reasons explained in another place (65).

Home pasteurization of milk is often of great value, as the milk is usually consumed before the spores have time to germinate and affect the milk (140).

63. *Chemical Preservatives.*—Many chemical substances have the power of preventing the growth of bacteria, and are often put in the milk by milkmen to prevent its souring. While contrary to law in most States, the use of these preservatives is not uncommon, as they save the expense of keeping the milk clean in the first place, the cost of pasteurizing and of the ice necessary to keep the milk cool, and besides the milk appears to families to be of exceptionally good keeping quality.

The following analyses and comments taken from the Year Book of the Department of Agriculture for 1900 will prove instructive in connection with chemical milk and food preservatives.

Dry Antiseptic.—Boric acid, 77.2 per cent; dry borax

equivalent to 42.98 per cent of crystallized borax. Directions: One ounce to ten pounds sausage or to four gallons milk.

Iceline.—A 1.92-per-cent solution of formaldehyde. Second analysis: A 3.66-per-cent solution formaldehyde. Directions: A tablespoonful to ten gallons of milk; one and one-half to two times as much to cream and buttermilk. A tablespoonful to each gallon of cream intended for cream puffs.

Freezine.—Liquid containing 5.19 per cent formaldehyde. Second analysis: Liquid containing 2.52 per cent formaldehyde. Directions: One tablespoonful to ten gallons of milk, six and two-thirds gallons of cream or buttermilk, or three and one-half gallons of ice cream; one tablespoonful to each gallon of cream intended for cream puffs.

Preserving Salts.—Six samples, Nos. 1 to 6 inclusive, are offered for different classes of foods and sold at different prices, but are identical in composition. They contain about 30 per cent of borax and 10 per cent of salt. Directions: From three to four ounces to one hundred pounds of food.

"*A*" *Preservaline.*—Percentage composition: Borax, 68; salt, 32. Second analysis: Borax, 75; salt, 19. Directions: Mix one-half pound with one hundred and fifty pounds of chopped meat; dust one pound over five hundred pounds of fresh meat; immerse poultry, drawn or undrawn, in a solution of one-quarter pound in two gallons of water for ten minutes.

Cream Albuminoid.—50.4 per cent boric acid, mixed with some proteid body, apparently gelatin (see 45).

No Ice Needed "M" Preservaline.—A four-per-cent solution of formaldehyde.

Special "M" Preservaline.—Solution containing 1.99 per cent formaldehyde.

Patent "M" Preservaline.—The sample contained 83 per cent of boric acid and 17 per cent of borax.

Milk Sweet.—A 3.90-per-cent solution of formaldehyde. A 10-per-cent solution of formaldehyde.

Ozone Antiseptic Compound.—The sample contained 51 per cent of boric acid and 72 per cent of borax, the high total (123) being due to partial dehydration. Directions: A tablespoonful to twenty or thirty quarts of milk or ten pounds of butter or cheese.

"*Preservative.*"—Sodium sulphite, 65 per cent; sodium sulphate, 34 per cent; colored with an aniline dye. Directions: One ounce to fifty pounds of chopped meat.

"It will be noticed that some preservatives have been examined by different analysts with widely varying results, indicating that the composition of some commercial preparations is not constant. One preservative was found to consist largely of salicylic acid in 1897 and of benzoic acid in 1900.

"The wide-spread use of these preparations is suggested by a case recently reported, where a preserving fluid had been added to milk first by the farmer, then by the collector to whom he sold, again by the wholesale dealer in the city, and finally by the retail dealer who delivered it to the consumer. The facts were developed by an investigation occasioned by the illness of children who drank the 'doctored' milk."

According to Bigelow: "A pound of meat treated

according to directions with a boric-acid preservative will contain from five to nineteen grains, while an infant who is fed each day a quart of milk so treated will receive eight grains, or a fair-sized dose for an adult." He also states that the use of formaldehyde "as a food preservative dates back to about 1895." . . . "Not only does it interfere with digestion to a marked extent, but it has been definitely proved that a compound is formed with the casein of milk which causes the latter, when treated with dilute acid such as exists in the gastric juice, to separate in hard lumps that are attacked only with difficulty by digestive ferments. The addition of formaldehyde to milk has become only too common, and, considering the fact that other and less objectionable preservatives will accomplish the same object, its use should be condemned in unqualified terms." Formaldehyde is the basis of many embalming fluids.

64. *Filtration and Clarification of Milk.*—Attempts have been made by enterprising milk dealers to improve their milk by filtering to remove dirt. The *appearance* of the milk is improved, as no sediment deposits if the milk stands for some time, but little or no effect is had in reducing the bacterial count.

Clarified milk was advocated for a time, it being cleaned or clarified by being passed through a separator which threw the foreign matter out as "separator slime" (44). This improves the milk in cleanliness, but breaks up the natural emulsion of the fat (42), interferes with cream rising, and changes the physical character of the milk. Babcock, after three years' experimenting with this process, stated: "Although cleaning milk with a separa-

tor has not accomplished all that we had hoped in the treatment of milk for cheese, we feel that it has been of great benefit, as it has in nearly every case improved the quality of the cheese, and the improvement has been more marked with tainted milks than with those in good condition."

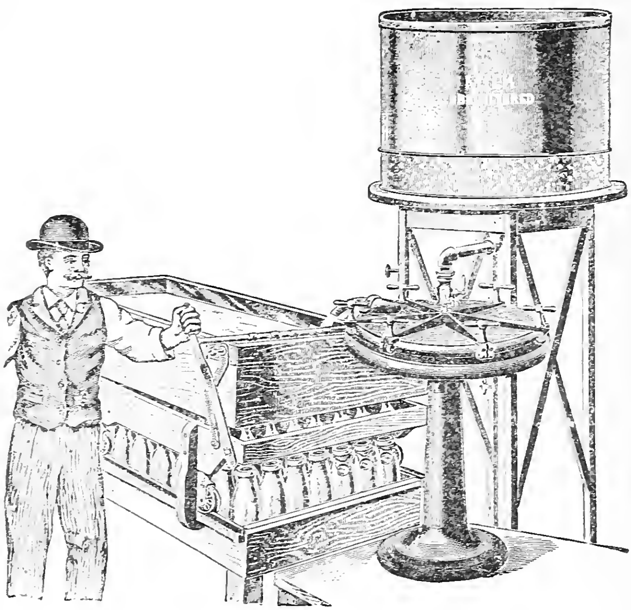


FIG. 30.—Milk Filter.

Filtered and clarified milks must be kept cool, or they will spoil as well as uncleaned milk.

65. *Cleanliness and Low Temperatures.*—If no bacteria found their way into milk it would remain unchanged indefinitely, except for the action of the enzymes natural to all milks (32 B). But no matter how much care is exercised, some bacteria will get into milk. If the tempera-

ture is kept below 45° F., they will not grow and affect the milk, and by the free use of ice it is possible to keep clean milk for several weeks in good condition. Without the use of ice even pasteurized milk will soon change. By care in producing milk the number of bacteria can be kept as low as that of commercial pasteurized milk (61). Thus, as far as keeping qualities go, this natural milk is as good as the pasteurized milk and much better in that no changes have been produced by heating. Milk containing large numbers of ordinary dairy bacteria will keep better and be better if ice is used, than if pasteurized and no ice is used to keep it cool afterward; but will spoil sooner than pasteurized milk if neither is iced.

In Europe, pasteurization is conducted by milk companies on a large scale, as ice is not used as in America. According to figures obtained through the United States Department of State, the estimated annual consumption of ice in England is 450,000 tons (long) and in London 160,000 tons, while Paris consumes about 65,000 tons. New York is thought to use 3,000,000 tons, and Chicago 2,000,000 tons of ice annually. The London *Daily Mail*, June 21, 1900, speaking of ice in London, says: "The demand is rapidly increasing now that the public have awakened to an intelligent appreciation of the cheapness and usefulness of the commodity."

66. At the Paris Exposition of 1900 there was an exhibit of American dairy products in charge of Maj. H. E. Alvord, chief of the Dairy Division of the United States Department of Agriculture. Among the articles exhibited was fresh milk and cream in bottles shipped regularly every two or three weeks from farms in Illinois,

New Jersey, and New York. To quote Major Alvord's report:

"Foreign visitors and expert milk dealers on the jury were hard to convince that nothing but 'cleanliness and cold' were used to preserve these products. . . . When finally satisfied as to the honesty of these exhibits, all three were promptly awarded gold medals. . . . No other country except France attempted to show natural milk and cream. The French exhibits of natural milk and cream were in striking contrast with those from the United States. At the July show there was not a single one of these local exhibits which was fit to use the day after reaching the grounds, and even in the moderate temperature of the May and September shows, the French products were all sour on the second or third day. But there were the natural products from America, just as they would be delivered to consumers in New York and Chicago, still perfectly sweet, a fortnight after being bottled and after a summer journey of three thousand or four thousand miles."

In a personal letter to the author, Major Alvord states: "The general milk service of Europe in all particulars is inferior to our own. This is especially true in France, where it is difficult to get natural milk, in the cities and larger towns, which will remain sweet even a few hours. Moreover, we are making more rapid and substantial improvements in this important branch of pure food supply than anywhere else in the world."

It will be seen that the milk business is not conducted on the same basis in Europe as in America. Therefore quotations and recommendations for pasteurization of

milk made by European observers have not much application in America.

There can be little doubt in the reader's mind as to which method of preserving milk is the best to follow. In the next chapter will be given a description of the methods of conducting the milk business in American cities.

CHAPTER XIII.

MARKET MILK.

67. THE great reduction in infant sickness and mortality that has generally followed an improvement in the milk supplies of a community makes a knowledge of the proper methods of producing and marketing milk of the greatest importance to physicians, sanitarians, and those having the care and feeding of infants.

What is wanted is a plentiful supply of fresh milk which is in practically the same condition as it was in the cow's udder as far as contamination is concerned, and at a price that will put it within the reach of all. It is *possible* to obtain such milk anywhere and at a trifling advance over the price charged for ordinary good milk, but not without some improvement in the methods of handling it.

In the previous chapter it was shown that most of the changes in milk are caused by bacteria that get into the milk (1) with dust and dirt during milking, and (2) from dirty dairy utensils after milking, and (3) that the great increase in numbers is the result of the milk not being cooled and kept cool; (4) also that the bacteria which produce poisons in milk are apt to come from stable filth, and that these can be kept out of the milk by having the cows, milker, and stable in a sanitary condition.

68. No idea of the conditions under which milk is produced or of the number of bacteria it contains can be

obtained by looking at it or even by tasting of it. Milk that would cause acute illness may not look or taste different from wholesome milk. It has been found, however, that milk containing few bacteria cannot be produced except under the most sanitary conditions; so counting the number of bacteria in a specimen of milk will tell whether the milk was properly cared for or not. If natural milk (60) contains few bacteria, it was produced under sanitary conditions and kept cool. If it contains large numbers, it is dirty or was not properly cooled, or both.

Unfortunately the counting of bacteria in milk can be done only by those especially trained, and is expensive work. The inability of the average person to determine the condition of milk has led to the organization of milk commissions, usually made up of disinterested medical men, who set a standard of wholesome milk and issue a certificate to any milkman whose milk is up to this standard, which he puts on his milk bottles. The purchaser is then sure of the quality of his milk. The idea of a milk commission originated with Dr. H. L. Coit, of Newark, N. J., and has been applied to one dairy near Newark with great success. This dairy is under the control of the commission in all of its details, and a high price, fifteen cents per quart, is charged for the milk. The population in the territory served by this dairy is as a whole well-to-do and can support it. In other sections of the country such a high price might be prohibitory and the conditions not suitable for such a dairy organization. In a large city a great many dairies would be needed to supply enough milk, and to organize special dairies would

be out of the question. Improvement can best be accomplished by working with milk dealers already established. An idea of how this may be done can be had from a short history of the organization of the Milk Commission in New York City.

For several years the author had been studying the milk supply of New York in connection with the subject of home modification of milk for infant feeding. To get an idea of how the milk business of the city was conducted, a business directory was taken and the financial rating of each milkman looked up. The bulk of the business was found to be in the hands of a few dealers—about fifty—some of whom were rated by the commercial agencies as having over $1,000,000 invested. These dealers handled about 1,250,000 quarts of milk daily.

A list of questions was sent to each of them, asking, among other things, if they sold milk to families in bottles or not, and at what price; under what conditions their milk was produced, and what percentage of fat it contained. From these answers and talks with the milkmen who called, the condition of the milk trade was easily discovered. It appeared that very few of the dealers had their own cows, but bought their milk from farmers. Milk-receiving stations called creameries are established at the railroad stations in dairy sections, and a number of farmers bring their milk to these stations, where it is mixed and prepared for shipment.

The milk business is divided sharply into two branches: (1) One selling milk in forty-quart cans to grocery stores, restaurants, etc.; and (2) the other in bottles to families direct.

(1) Price is the first consideration in "grocery milk," and the milk is bought of the farmers at prices that barely pay for the cow's feed (72). The milk is then standardized—that is, adjusted so that it will contain as nearly as possible three per cent of fat and twelve per cent of total solids, the minimum quantities allowed by law, any excess

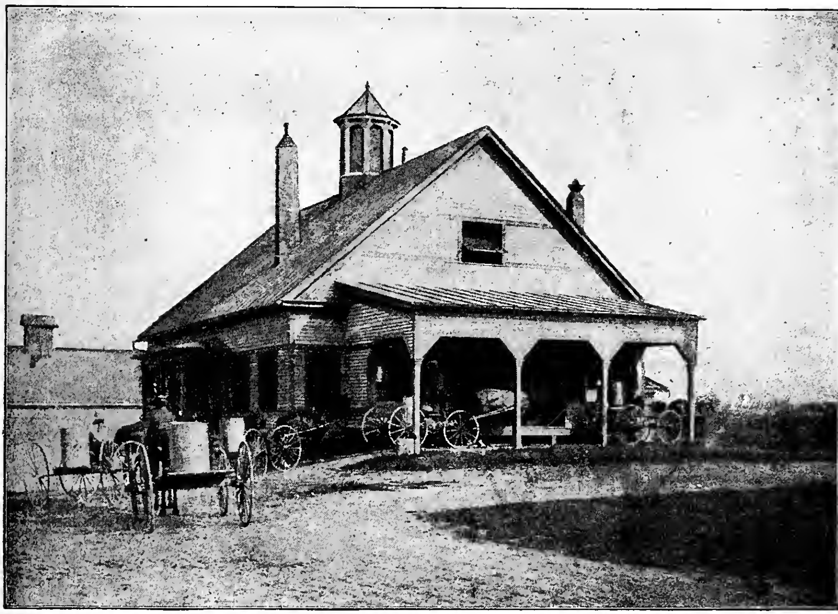


Fig. 31.—Milk Receiving Station or Creamery.

of fat being removed and sold as cream. "Grocery milk" retails in New York at from three to four cents per quart.

(2) For the milk intended for family trade the farmers receive better prices and more care is expended on it. Some dealers filter or clarify it (64). Others allow the cream to rise and draw off some of the under milk, so

that the remaining milk will show more cream when delivered in bottles to the families.

The milk is then bottled by machinery and packed in cases containing cracked ice. Much of this milk is good; some of it all that could be desired. The average retail price charged is eight cents per quart.

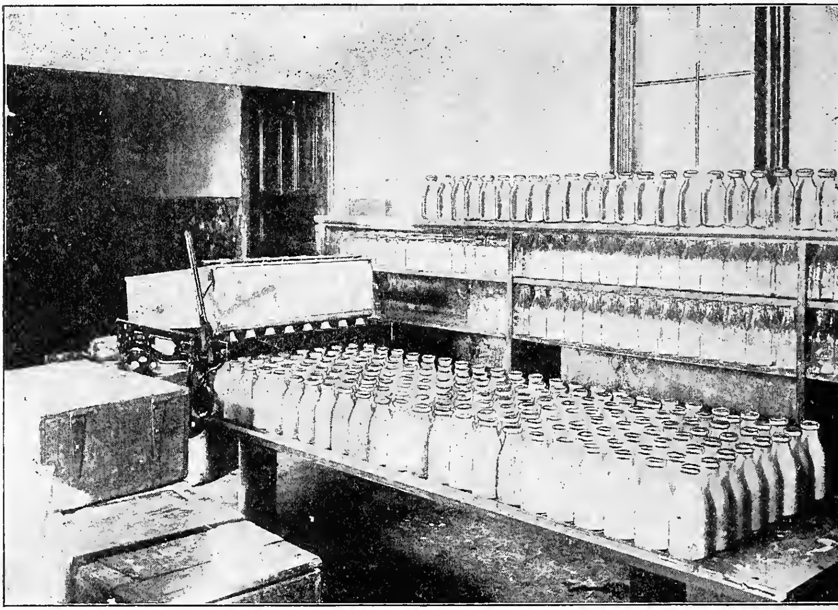


FIG. 32.—Bottle Filler.

Many of these dealers have spent considerable sums of money trying to improve their milk, but often they have not worked intelligently, not knowing where to expend to the best advantage. It is not to be expected that they would know how, as many started as drivers of milk wagons and know nothing of bacteriology or practical sanitation.

69. Having this information, the writer read a paper on "How the Milk Supply of New York May be Improved," at a meeting of the Medical Society of the County of New York, to which the milkmen were invited. At this meeting Maj. H. E. Alvord, chief of the Dairy Division of the United States Department of Agriculture, and Prof. H. W. Conn spoke of dairy conditions and bacteriology, and the milkmen presented their side of the question.

A committee, with the author as chairman, was appointed to look into the milk-supply question, and the present milk commission resulted. Details of the investigations conducted by this committee will be found in the *Medical Record*, October 19th, 1901.

The milk dealers were invited to meet with the committee, and many did. The committee explained the object of the movement and asked them how, in their opinion, the problem could be best attacked. The dealers soon found that the object was to *help* them and not to harass or burden them with unnecessary restrictions, and they took hold with hearty good-will. The standard determined on for milk for certification was not over 30,000 bacteria per cubic centimetre, acidity not over .2 per cent, and at least 3.5 per cent of butter fat. This is a high standard when it is considered that some of the milk has to be brought several hundred miles by railroad during hot weather. At first none of the dealers could supply milk up to the standard, but by visiting the farmers who produced the milk and showing them how to arrange their stables, clean their cows, hands, and dairy utensils, it was found that milk well within the standard

could be produced in abundance and at a small advance in price over that of the ordinary bottled milk.

70. Here is a practical example of progression in methods of handling milk, furnished to the author by a large New York milk company. The manager of this company originally started with a single milk wagon and delivered milk to families himself, dipping it out of cans. As bottled milk began to be handled, he and other small dealers combined and established creameries or bottling stations (68), and now have a large business with families. This company has several bottling stations, at each of which the milk of about twenty farmers is mixed and bottled.

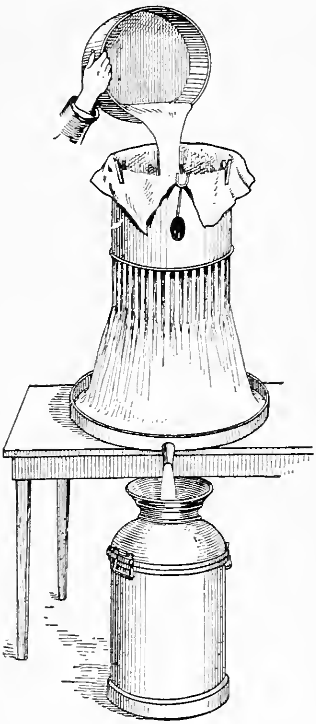


FIG. 33.—Milk Cooler for Use with Water.

By experience it had been found that the milk could not arrive in New York in good condition unless cooled soon after milking, so no milk would be received from the farmers that was warmer than 60° F. The cooling was done by pouring the milk over the surface of a cooler containing well or spring water.

One day in the middle of August, 1901, the bacteria in the milk of each farmer that supplied one of these creameries were counted; the farmers were then shown

how, by cleaning out their stables better, wiping the cows with a damp cloth, and keeping dusty hay out of the stable during milking time, the bacteria in the milk would be reduced in numbers; and two or three weeks later another count was made. Here are the counts before any suggestions were made, and after they were put into effect. In some instances remarkable reductions in count are shown. It cost no more to produce the milk at one time than the other.

BACTERIA PER CUBIC CENTIMETRE.

Farmer.	Before changes were made. Middle of August.	After changes were made. About September 1st.
No. 1	44,800	29,300 morning. 23,600 night.
No. 2	83,400 morning. 38,400 night.	41,400 morning. 37,200 night.
No. 3	65,000	32,000 morning. 321,000 night.
No. 4	32,000	32,000 morning. 215,000 night.
No. 5	57,600 morning. 70,400 night.	12,000 morning. 172,000 night.
No. 6	460,800	15,000 morning. 47,200 night.
No. 7	578,000	110,200 morning. 31,400 night.
No. 8	76,800	27,700 morning. 59,100 night.
No. 9	63,500	10,200 morning. 19,200 night.
No. 10	102,400	18,900 morning. 19,200 night.
No. 11	137,000	44,800
No. 12	99,300	28,200
No. 13	9,827,000	21,300 morning. 64,000 night.
No. 14	121,600	26,700 morning. 12,800 night.
No. 15	80,000	210,400 morning. 83,200 night.
No. 16	76,800	518,400
No. 17	159,200	16,100
No. 18	349,200	21,400 morning. 25,600 night.

One of these farmers was selected to produce milk for certification, and here are the counts of his milk when taken from the delivery wagon in New York:

1901—December	37,100	
December	17,000	
December	26,000	
December	36,000	
1902—January	19,000	
January	11,000	
January	72,000	
January	96,000	
February	150,000	
February	17,000	at farm.
February	450,000	at creamery.
February	12,000	
February	7,750	
February	2,700	
March	3,450	
March	3,700	
March	4,750	
March	41,000	
April	4,800	
April	4,000	
April	5,200	
April	11,000	
May	1,000	
May	20,000	
May	5,800	
May	17,000	
June	12,000	
June	11,500	

The high counts of January and February were found to be caused by a little water, used in washing the bottles at the creameries, remaining in the bottles. After the bottles were sterilized by steam before being filled the count became low. The one high count in March was found to be caused by laying a new floor in the creamery. Eternal vigilance is the price of low bacterial count.

The average price the farmer received for this milk during nine months was 3.53⅔ cents per quart. During June, 1901, the price was 2.57⅔ cents, and during November, December, and January, 1902, 4.06⅔ cents. The other farmers saw he was making money, and wished to be allowed to furnish extra clean milk as fast as it could be sold in New York. One cent a quart above the prices these farmers receive for their ordinary milk, which is

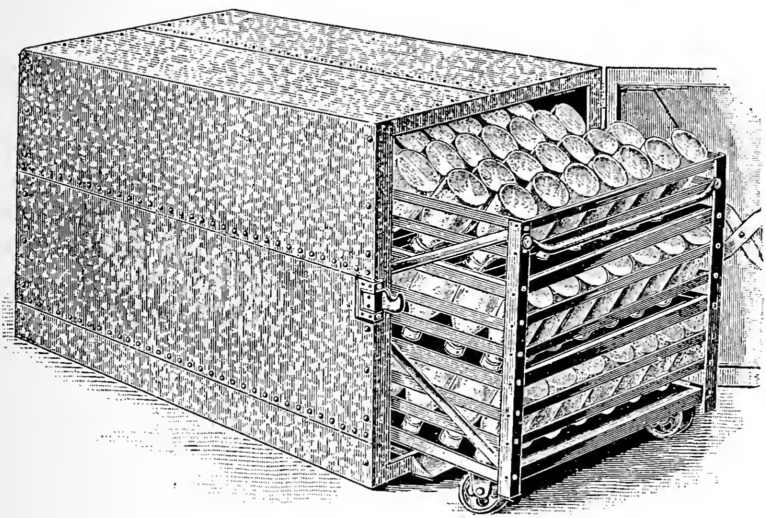


FIG. 34.—Bottle Sterilizer.

used for bottling, will enabled them to produce "certified milk." It is a mistake to imagine that costly stables are necessary. Such milk can be produced in the barn of any progressive farmer.

Undoubtedly hospitals and institutions could make yearly contracts for this milk at five cents per quart in bulk and at seven cents in bottles. If enough demand

could be created from the general public, so the extra expense of delivering small lots would be reduced, it would not sell at ten cents, the price charged, but at eight cents per quart, the present price for good bottled milk in New York. In small towns and cities it could be sold at six cents, as the freight charges into New York are about one cent a bottle, and these would be unnecessary when the milk was produced near by.

71. *Grocery Milk.*—It is almost hopeless to try to improve "grocery milk," as no one in particular is responsible for it. The price the farmer receives for it (72), barely covering cost of the cow's feed, prohibits exercise of the necessary care on his part, and the continual opening of the milk can in the grocery store makes easy the entrance of germ-laden dust (62). The transportation from the farmer to the store is obtained at the lowest price, so that conditions preventing bacterial growth cannot be had. Legislation cannot compel a farmer to produce his milk at a loss, and the population that consumes "grocery milk" would vote out of office authorities that prohibited its sale or advanced its cost. Large numbers of ordinary dairy bacteria in milk are not harmful to adults. Buttermilk contains millions of them to the teaspoonful, and no one is afraid to drink it. The great majority of *adults* would rather run the risk of using "grocery milk" than pay double price for "certified milk" with its *to them* slightly increased safety. With infants, the increase of safety by using "certified milk" is very great, and few parents would let three or four cents a day additional cost prevent their purchasing it for their children, if they knew its value.

72. *Cost of Producing Milk.*—The full force of the statements concerning "grocery milk" will be appreciated by a glance over the following figures, showing what farmers receive, and the cost of producing a quart of milk, also the profit the farmer is liable to make from a cow during a year.

According to the *New York Farmer*, a dairy paper, the average prices the farmers of New York State have actually received for the milk shipped to New York in forty-quart cans have been during

	Cents per quart.		Cents per quart.
1897	1.691–1.841	1900	2.084–2.237
1898	1.735–1.885	1901	1.969–2.120
1899	1.879–2.029		

and the prices paid by one of the largest milk-condensing companies, which requires a fairly clean milk, were during 1901:

1901.	Cents per quart.	1901.	Cents per quart.
January	3.33¼	July	2.04½
February	3.11¾	August	2.36½
March	2.90¼	September	2.79½
April	2.47¼	October	3.01
May	2.15	November	3.22¼
June	1.72	December	3 33¼

Now glance at the cost of producing milk.

73. The average cost of the milk of a herd of twenty cows at the New York (Cornell) Experiment Station for a year was .625 cents per one hundred pounds, or 1.33 cents per quart. The milk of one cow cost $1.48 per one hundred pounds, or 3.15 cents per quart.

Tests of pure-bred cattle at the Maine, New York,

and New Jersey experiment stations show the following costs:

Breed.	Average yield per year in pounds.	Average per cent. of fat.	Cost of 100 pounds milk, Cents.	Cost per quart
Short Horn	8,696	3 97	78 7	1.66
Holstein Friesian	8,215	3 43	74 7	1.59
Ayrshire	6,909	3 60	78.5	1.67
Guernsey	6,210	5.20	82.8	1.76
Jersey	5,579	5.40	94.7	2.06
Devon	3,984	4 60	94.0	2.05

Individual cows of the herd of the Wisconsin Experiment Station made the following showing during the year 1900:

Breed.	Yield, pounds.	Fat, Per cent.	Cost of food, Dollars.	Cost of 100 pounds of milk, Cents.	Cost per quart, Cents.	Yearly profit, 1900.	Yearly profit, 1899.
Grade Short Horn	10,131.7	4.7	39.60	39.0	0.83	92.23	79.86
Grade Short Horn	10,100.0	4.15	36.44	36.0	.76	74.00	54.43
Grade Short Horn	7,833.0	4 0	38.19	48.7	1.03	41.06	Not given.
Grade Short Horn	6,973.2	4.2	27.16	39.1	.83	47.27	Not given.
Grade Short Horn	7,996.7	4.1	26.22	32.7	.70	57.48	20.86
Grade Jersey	5,775.3	5.7	32.18	56.1	1.20	49.32	Not given.
Grade Jersey	7,473.0	5.3	32.27	43.1	.92	66.20	57.14
Grade Guernsey	6,095.0	5.5	26.89	44.1	.94	57.03	.07
Holstein Friesian	9,561.4	3.5	38.21	39.0	.83	52.30	Not given.
Holstein Friesian	8.868.9	3.8	37.39	42.1	.90	54.08	Not given.

These ten cows netted $590.97, or $59.09 per cow during a year, or 16 cents a day. In the foregoing costs of milk, *no allowance is made for labor*, the cow's manure being said to be worth her care.

It has been stated by H. E. Alvord that many authorities believe that in the United States one-third of the cows are kept at a loss, one-third about pay for themselves, and one-third pay a profit to their owners. If at the experiment stations, the most scientific dairymen, with selected stock, which produce milk at less than one cent

a quart, can show a yearly profit of only $59.09 per cow, the other experiment station herds whose milk-cost ranged from 1.55 to 2.9 cents per quart would not have paid expenses with the same prices for their products. At the New York Experiment Station (Geneva) it was calculated the herd would pay $19.80 per cow, if milk sold at 2¾ cents per quart.

With these costs and profits obtained by experts with selected cows, what can be the ordinary farmer's profits at the prices he receives?

Farrington, reporting on a herd of twelve cows tested on a farm for a year by experts from the Wisconsin Experiment Station, says: "The entire herd only paid a profit of $75, and three of the twelve cows paid $50 of this amount, while the combined profit of the other nine was only $25. . . . There were three cows which did not produce milk enough to pay for their feed." The daily profit each cow paid was *one cent.*

Farmers cannot be expected to take additional care of their milk without extra compensation. Higher prices to the farmer is the solution of the milk problem, and the dealer should also have extra compensation for any additional labor and care on his part.

74. *Milk Commission's Regulations.*—Every milk commission will have to adapt its regulations to local conditions. No better guide can be followed than the "Fifty Dairy Rules"* of the United States Department of Agriculture.

The following circulars sent out to the milkmen by

* A copy of these can be had free of charge by applying to the Secretary of Agriculture, Washington, D. C.

the New York Commission may prove interesting. It will be noticed that the cost to the dealers for examination of their milk is as low as one-tenth of one cent a quart, and will be lower as the output increases.

CIRCULARS.

1st. "Certified Milk."

CIRCULAR OF INFORMATION CONCERNING THE REQUIREMENTS OF THE MILK COMMISSION OF THE MEDICAL SOCIETY OF THE COUNTY OF NEW YORK FOR "CERTIFIED" MILK.

The Commission appointed by the Medical Society of the County of New York to aid in improving the milk supply of New York City invites the co-operation of the milk-dealers and farmers in attaining that end. The sale of pure milk is of advantage to those furnishing it, as well as to those who use it. The Commission has undertaken to assist both consumer and producer by fixing a standard of cleanliness and quality to which it can certify, and by giving information concerning the measures needful for obtaining that degree of purity.

The most practicable standard for the estimation of cleanliness in the handling and care of milk is its relative freedom from bacteria. The Commission has tentatively fixed upon a maximum of 30,000 germs of all kinds per cubic centimetre of milk, which must not be exceeded in order to obtain the indorsement of the Commission. This standard must be attained solely by measures directed toward scrupulous cleanliness, proper cooling, and prompt delivery. The milk certified by the Commission must contain not less than four per cent. of butter fat, on the average, and have all other characteristics of pure, wholesome milk.

In order that dealers who incur the expense and take the precautions necessary to furnish a truly clean and wholesome milk may have some suitable means of bringing these facts before the public, the Commission offers them the right to use caps on their

milk jars stamped with the words, "Certified by the Commission of the Medical Society of the County of New York." The dealers are given the right to use these certificates when their milk is obtained under the conditions required by the Commission and conforms to its standards.

The required conditions are as follows:

1. THE BARNYARD.—The barnyard should be free from manure and well drained, so that it may not harbor stagnant water. The manure which collects each day should not be piled close to the barn, but should be taken several hundred feet away. If these rules are observed not only will the barnyard be free from objectionable smell, which is always an injury to the milk, but the number of flies in summer will be considerably diminished. These flies in themselves are an element of danger, for they are fond of both filth and milk, and are liable to get into the milk after having soiled their bodies and legs in recently visited filth, thus carrying it into the milk. Flies also irritate cows, and by making them nervous reduce the amount of their milk.

2. THE STABLE.—In the stable the principles of cleanliness must be strictly observed. The room in which the cows are milked should have no storage loft above it; where this is not feasible, the floor of the loft should be tight, to prevent the sifting of dust into the stable beneath. The stables should be well ventilated, lighted, and drained, and should have tight floors, preferably of cement. They should be whitewashed inside at least twice a year, and the air should always be fresh and without bad odor. A sufficient number of lanterns should be provided to enable the necessary work to be properly done during dark hours. There should be an adequate water supply and the necessary wash-basins, soap, and towels. The manure should be removed from the stalls twice daily, except when the cows are outside in the fields the entire time between the morning and afternoon milkings. The manure gutter must be kept in a sanitary condition, and all sweeping and cleaning must be finished at least twenty minutes before milking, so that at that time the air may be free from dust.

3. WATER SUPPLY.—The whole premises used for dairy purposes, as well as the barn, must have a supply of water absolutely

free from any danger of pollution with animal matter, and sufficiently abundant for all purposes and easy of access.

4. The Cows.—The cows should be examined at least twice a year by a skilled veterinarian. Any animal suspected of being in bad health must be promptly removed from the herd and her milk rejected. Never add an animal to the herd until it has been tested with tuberculin and it is certain that it is free from disease. Do not allow the cows to be excited by hard driving, abuse, loud talking, or any unnecessary disturbance. Do not allow any strongly flavored food, like garlic, which will affect the flavor of the milk, to be eaten by the cows.

Groom the entire body of the cow daily. Before each milking wipe the udder with a clean damp cloth, and when necessary wash it with soap and clean water and wipe it dry with a clean towel. Never leave the udder wet, and be sure the water and towel used are clean. If the hair in the region of the udder is long and not easily kept clean, it should be clipped. The cows must not be allowed to lie down after being cleaned for milking until the milking is finished. A chain or rope must be stretched under the neck to prevent this.

All milk from cows sixty days before and ten days after calving must be rejected.

5. The Milkers.—The milker should be personally clean. He should neither have nor come in contact with any contagious disease while employed in milking or handling milk. In case of any illness in the person or family of any employee in the dairy, such employee must absent himself from the dairy until a physician certifies that it is safe for him to return.

Before milking, the hands should be thoroughly washed in warm water with soap and a nail brush and well dried with a clean towel. On no account should the hands be wet during the milking.

The milking should be done regularly at the same hour morning and evening, and in a quiet, thorough manner. Light-colored washable outer garments should be worn during milking. They should be clean and dry, and when not in use for this purpose should be kept in a clean place protected from dust. Milking

stools must be kept clean. Iron stools, painted white, are recommended.

6. Helpers other than Milkers.—All persons engaged in the stable and dairy should be reliable and intelligent. Children under twelve years should not be allowed in the stable during milking, since in their ignorance they may do harm, and from their liability to contagious diseases they are more apt than older persons to transmit them through the milk.

7. Small Animals.—Cats and dogs must be excluded from the stables during the time of milking.

8. The Milk.—The first few streams from each teat should be discarded, in order to free the milk ducts from milk that has remained in them for some time and in which bacteria are sure to have multiplied greatly. If in any milking a part of the milk is bloody or stringy or unnatural in appearance, the whole quantity of milk yielded by that animal must be rejected. If any accident occurs by which the milk in a pail becomes dirty, do not try to remove the dirt by straining, but reject all the milk and cleanse the pail. The milk pails used should have an opening not exceeding eight inches in diameter.

Remove the milk of each cow from the stable immediately after it is obtained to a clean room and strain it through a sterilized strainer.

The rapid cooling of milk is a matter of great importance. The milk should be cooled to 45° within one hour. Aeration of pure milk beyond that obtained in milking is unnecessary.

All dairy utensils, including bottles, must be thoroughly cleansed and sterilized. This can be done by first thoroughly rinsing in warm water, then washing with a brush and soap or other alkaline cleansing material and hot water, and thoroughly rinsing. After this cleansing, they should be sterilized with boiling water or steam and then kept inverted in a place free from dust.

9. The Dairy.—The room or rooms where the bottles, milk pails, strainers, and other utensils are cleaned and sterilized should be separated somewhat from the house, or when this is impossible have at least a separate entrance, and be used only for

dairy purposes, so as to lessen the danger of transmitting through the milk contagious diseases which may occur in the home.

Bottles, after filling, must be closed with sterilized discs, and capped so as to keep all dirt and dust from the inner surface of the neck and the mouth of the bottle.

10. Examination of the Milk and Dairy Inspection.—In order that the dealers and the Commission may be kept informed of the character of the milk, specimens taken at random from the day's supply must be sent weekly to the Research Laboratory of the Health Department, where examinations will be made by experts for the Commission; the Health Department having given the use of its laboratories for this purpose.

The Commission reserves to itself the right to make inspections of certified farms at any time and to take specimens of milk for examination. It also reserves the right to change its standards in any reasonable manner upon due notice being given to the dealers.

After January 1, 1902, the expenses incurred in making the regular milk examinations and inspections will be borne by the dealers. In fixing the charges each farm or group of farms will be considered a unit. The Secretary of the County Medical Society will send bills to the dealers about the middle of each month. Prompt payment is requested.

The monthly charges, which are intended to cover all expenses, will be as follows:

For each group of farms	sending daily	less than 100	quarts	$8.00
"	"	100 to 200	"	10.00
"	"	200 to 500	"	12.00
"	"	over 500	"	15.00

2d. "Inspected Milk."

CIRCULAR OF INFORMATION CONCERNING THE REQUIREMENTS OF THE MILK COMMISSION OF THE MEDICAL SOCIETY OF THE COUNTY OF NEW YORK FOR "INSPECTED" MILK.

The Commission appointed by the Medical Society of the County of New York to aid in improving the milk supply of New York City has formulated the following requirements, affecting

the farms inspected by it and the handling of the milk obtained at those farms. The Commission offers those dealers complying with these requirements the right to use caps on their milk bottles, stamped: "INSPECTED. MILK COMMISSION MEDICAL SOCIETY, COUNTY OF NEW YORK."

The requirements are as follows:

1. THE BARNYARD.

(a) It must contain no manure in summer and none in contact with the stable in winter.

(b) It must be well drained and kept reasonably clean.

2. THE STABLES.

(a) The ventilation and light must be sufficient for the number of cows stabled, so that the barn shall be light and the air never close.

(b) The floor shall be of wood or cement.

(c) The ceiling shall be tight, if a loft above is used.

(d) Basins, hand brushes, clean water, soap and clean towels shall be provided in the barn or adjacent dairy room.

(e) The stable shall be whitewashed in the fall, and in the spring if necessary.

(f) A sufficient number of lanterns shall be provided to allow the milking to be carried on properly.

(g) Clean the ceiling and sidings once a month.

(h) The bedding shall be shavings, sawdust, dried leaves, cut straw, or other material that meets with the approval of the Commission.

(i) The soiled bedding must be removed daily.

(j) The manure must be removed daily from the stalls and open manure-gutter. If a covered manure-gutter is used, it must be kept in a sanitary condition.

(k) The application of land-plaster or lime on the floor daily is recommended.

(l) Sweep the entire floor outside of the stalls daily at least an hour before milking is begun.

3. WATER SUPPLY.

Pure water must be used for all purposes. It must be accessible and abundant.

4. The Cows.
   (a) Discard milk containing mucus or blood and that from any diseased cow.
   (b) Reject milk from any animal forty-five days before and six days after calving.
   (c) The food given must be suitable both in amount and kind and must not give a disagreeable flavor to the milk.
   (d) Keep the cows clean on flanks, belly, udder, and tail.
   (e) Clip long hairs about udders and clip the tail sufficiently to clear the ground.
   (f) The cows must be kept from lying down between the cleaning and milking. The best means of accomplishing this is by throat latches.
   (g) Clean the udder thoroughly before milking.

5. The Milkers.
   (a) No milker or assistant shall have any connection with the milk at any stage of its production if he has any communicable disease, or if he has been exposed to scarlet fever, diphtheria, typhoid fever, or smallpox.
   (b) After having everything prepared for milking, thoroughly wash the hands with soap, water, and brush, so that they may be clean when milking is begun.
   (c) The hands and teats must be kept dry during milking. If they become moistened with milk, they must be wiped dry with a clean towel.
   (d) Suitable clean outer garments, such as overalls and jumpers, must be put on before milking.

6. Utensils.
   (a) Strainers, whether metal, gauze, or cotton, must be absolutely clean when used for straining milk.
   (b) All dairy utensils must be absolutely clean and free from dust.

7. The Milk.
   (a) The milk must not be adulterated in any way.
   (b) It must average four per cent. of butter-fat.
   (c) Cooling must be begun within thirty minutes after the milking. The temperature of the milk must be reduced

to 55° F. within two hours after milking and to 50° F. within three hours and kept below that temperature until delivered to the consumer.

(d) When delivered to the consumer the milk must not average over 100,000 bacteria per cubic centimetre from May 1st to September 30th, and not over 60,000 bacteria per cubic centimetre from October 1st to April 30th. If the Commission's requirements are fulfilled, the bacteria will not be in excess of the number permitted.

8. INSPECTIONS.

(a) The farms which furnish "Inspected" milk must always be open to inspection by the Commission.

(b) Samples of milk must be regularly submitted for bacteriological examination once a month.

For cooling the milk to the best advantage, straining through cheese-cloth or a Turkish towel into a can placed in ice-water is better than the commercial coolers (70). All utensils should be simple, with tight seams (58), and steamed if possible before using (58).

The necessity of rejecting a cow from a herd simply because she reacts to the tuberculin test (55) is open to doubt. A difference is now being drawn between tuberculin tuberculosis and clinical tuberculosis. If only a small gland is affected the cow will respond to the tuberculin test; the disease may not spread in the body, and the cow's milk will not contain tubercle bacilli. When clinical symptoms of tuberculosis appear, the cow's milk should not be used as food.

Bacterial Standard for Certified Milk.—In the author's opinion thirty thousand bacteria to the cubic centimetre is a small enough number to merit certification of milk. If enough care is taken to keep the number as low as this, most putrefactive bacteria will be kept out (54). The

precautions necessary to keep below this number greatly increase the cost of milk and defeat the object in view, viz., to place within the reach of all wholesome milk at a moderate price, as few milkmen can keep up to a higher standard, no matter what price they obtain, and the high price will curtail consumption.

CHAPTER XIV.

METHODS OF TESTING MILK.

75. For most practical purposes it is necessary to determine only the percentage of fat and solids not fat in milk. From (1) the percentage of fat and (2) specific gravity, the (3) solids not fat can be readily determined. These tests tell whether the milk has been watered or skimmed or both.

Fig. 35.—Babcock Milk Test Bottle. (Farrington and Woll.)

Fat Test.—The most generally used method of testing fat in milk and cream is that invented by Dr. S. M. Babcock, of the Wisconsin Experiment Station. In this test the ingredients of milk other than fat are dissolved by sulphuric acid in a special bottle with a graduated neck. Hot water is added, and the bottle is whirled in a centrifuge until the melted fat rises into the neck, when its percentage can be read.

The necks of the bottles for *milk* testing are graduated from 0 to 10 per cent, with subdivisions of .2 per cent, and contain 2 c.c. between the 0 and 10 marks, or 10 per cent of 20 c.c. If the milk and melted fat had the same specific gravity as water, 20 c.c. of milk would be used in making a test. However, 17.44 c.c. of

milk are placed in the bottles, as 2 c.c. of melted butter fat weigh but 1.8 grams and 17.44 c.c. of milk weigh ten times as much, or 18 grams. The percentage reading is thus by weight, not volume.

Cream bottles are graduated from 0 to 35 per cent, with subdivisions of .5 per cent. A little less than 18 c.c. of cream is placed in the bottle, as this quantity weighs 18 gm., the excess of fat lighter than water offsetting the solids heavier than water in the cream.

FIG. 36.—17.6 c.c. Pipette. (Farrington and Woll.)

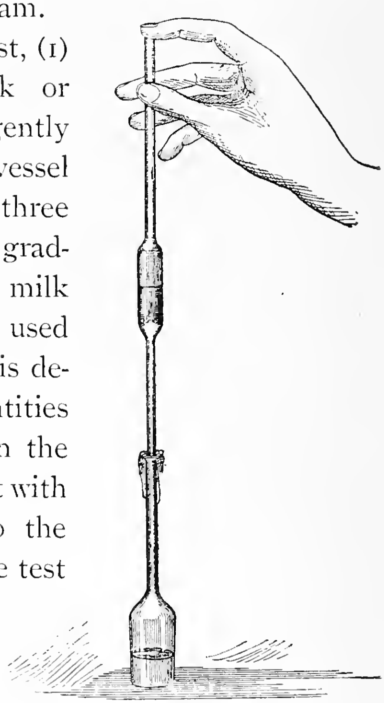


FIG. 37.—Wrong Way of Emptying Pipette. (Farrington and Woll.)

In making the test, (1) the sample of milk or cream is mixed by gently pouring from one vessel into another two or three times. (2) A pipette graduated for 17.6 c.c. of milk or 18 c.c. of cream is used for measuring, as this delivers the proper quantities into the bottle when the last drop is blown out with the breath. (3) To the milk or cream in the test bottle is added about 17.5 c.c. of commercially pure sulphuric acid, specific gravity, 1.82. One cubic centimetre more or less makes little difference. The color at the junction of the milk with the acid is greenish with pure milk.

If formaldehyde is present there is a violet ring and the curd dissolves slowly. A ring other than greenish suggests preservatives. (4) The bottle is now gently shaken until all the curd that forms is dissolved, care being taken not to allow any specks to get into the neck. The mixed milk and acid becomes very hot and melts the

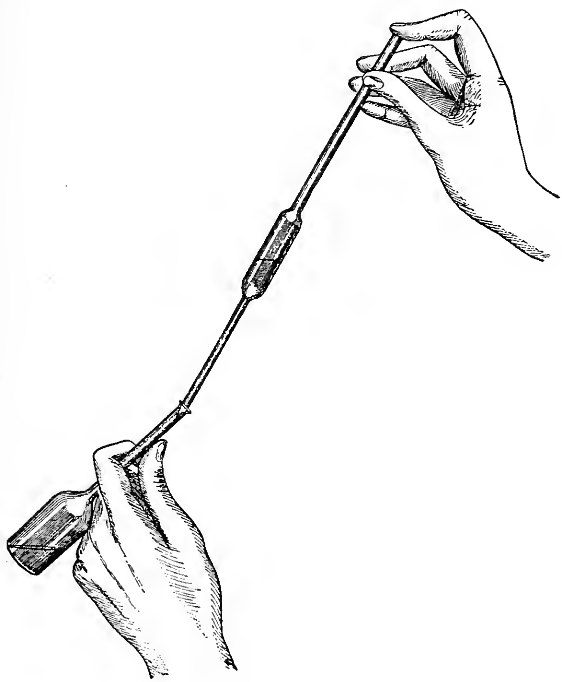


FIG. 38.—Right Way of Emptying Pipette. (Farrington and Woll.)

fat. It is always well to make tests in duplicate to allow for accidents during the process. (5) The bottles are then placed in a centrifuge and whirled for five minutes. (6) Boiling water is added up to the base of the neck and the bottles are whirled for a minute or two. (7) Again, boiling water is added so the melted butter

fat will reach nearly to the top mark on the scale, and the bottles are again whirled for one minute. (8) Before reading the percentage of fat it is well to pour some boiling water over the outside of the necks of the bottles with a pipette to be sure the butter fat is melted. If the acid was too strong the fat may appear charred, and if too weak the curd will not be entirely dissolved.

Fig. 39.—Acid Measure. (Farrington and Woll.)

In selecting Babcock milk-testing machines, those that open by removing a cover on the plan of that in the illustration will be found most convenient.

The glassware should be purchased of a dealer who will guarantee its accuracy. All dairy supply houses carry these testing outfits.

76. *Specific gravity.*—Before the invention of the Babcock fat test, milk was generally tested with a lactometer from which its specific gravity could be determined, but this test has little or no value by itself. The specific gravity of normal milk varies from 1.029 to 1.035, while that of skimmed milk is as high as 1.036. The presence of the fat, which is lighter than water, makes the specific gravity of normal milk less than that of skimmed milk, the solids of which are heavier than water. Milkmen soon found that by skimming off the cream and adding water to the skimmed

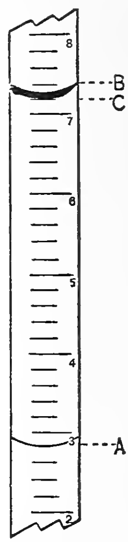


Fig. 40. — Fat in Neck of Test Bottle. Reading should be made between *A* and *B* not between *A* and *C*. (Wing.)

milk, the specific gravity of the diluted skimmed milk could be made the same as that of normal milk. For this reason the lactometer has little value by itself for testing milk. But if, in addition to the specific gravity obtained from the lactometer reading, the percentage of fat is determined, the total solids and solids not fat in a specimen of milk can be quickly ascertained. Skimming and watering of milk can thus be readily detected.

There are two forms of lactometers in general use, known as the Board of Health and Quevenne's lactometers. The scale on the Board of Health lactometer is divided into 120 degrees, the 100 mark indicating a specific gravity of 1.029 and the 120 mark of 1.035, which is the range for normal milk. As 100 degrees on the lactometer scale equal a specific gravity of 1.029, multiplying any degree on the scale by .29 will give the specific gravity figures when 1.0 is placed to the left of the result.

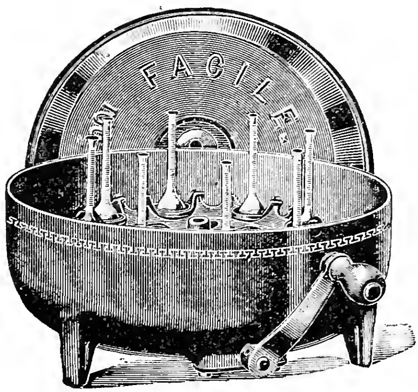


Fig. 41.—Babcock-Milk Testing Machine.

The scale on the Quevenne lactometer reads from 15 to 40, and gives the specific gravity directly by placing 1.0 to the left of the figures on the scale (77).

Tables have been published by several chemists which show the percentages of solids not fat in milk for each half degree of specific gravity and each one-fifth per cent of fat, which are exact enough for all practical purposes,

being within a small fraction of one per cent of the results obtained by weighing the solids. The tables of different chemists show slight differences, which probably result from the use of different methods of analysis and weighing. In America the table constructed by Babcock is largely used. It is not given here because the following simple rule given by Farrington and Woll makes it unnecessary.

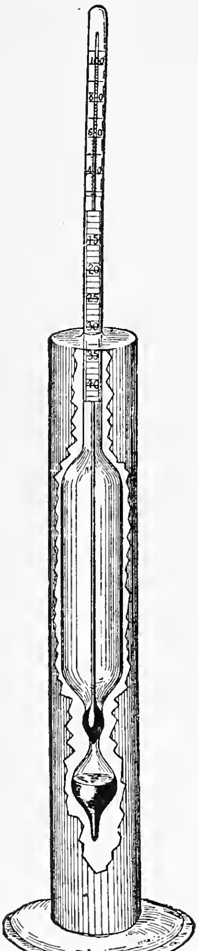


FIG. 42.—Quevenne Lactometer Floating in Milk. (Farrington and Woll.)

Rule: Divide the lactometer reading (Quevenne's scale) by 4, and add to this one-fifth of the percentage of fat; result, *solids not fat*. By adding to this the weight of fat, *total solids* are obtained (28).

77. *How to Use Lactometers.*—Mix the sample of milk by gently pouring it from one vessel into another, so that the fat shall be uniformly distributed. Have the lactometer dry and lower it gently into the milk, preferably in a hydrometer jar. Always have the milk at a temperature within ten degrees of 60° F. Lactometers combined with thermometers can be had at any dairy supply house. *Do not allow over half a minute to clapse before taking the reading.* If the Board of Health lactometer is used, multiply the reading by .29 to get the Quevenne reading. Then for every degree of temperature above

60° F. *add* .1 degree specific gravity, and *subtract* .1 degree for each degree of temperature below 60° F. Milk should not be tested within three hours of leaving the cow, as erroneous results are obtained, the reason for which is not known.

Example.—A specimen of milk is found to contain four per cent of fat, and the Board of Health lactometer read 114° at 55° F., or 110° at 65° F.

$$\left.\begin{array}{l} 114 \times .29 = 33.06 - .5 \text{ temp. correction} = 32.56 \\ 110 \times .29 = 31.90 + .5 \text{ temp. correction} = 32.40 \end{array}\right\} \text{of Quevenne scale.}$$

Place 1.0 to the left of these results and remove the decimal point from the degrees, and specific gravity 1.03256 or 1.0324 is the result.

	Per cent.	
One fifth of the percentage of fat (4 per cent. ÷ 5)	0.8	
One-fourth of the Quevenne lactometer reading (32.5° ÷ 4)	+ 8.12	
	8.92	solids not fat.
	+ 4.00	fat.
	12.90	total solids.

This method is accurate for milks containing up to 6 per cent of fat.

78. In paragraph 38 will be found complete analyses of twenty-nine different lots of mixed milks, ranging by slight percentages from 3 per cent to 5.25 per cent of fat and 11.60 per cent to 14.94 per cent total solids.

79. *Legal Standards.*—In nearly all of the States which have dairy laws the legal requirement is that milk shall contain at least 3 per cent of butter fat and 12 per cent of total solids. Some States also require that there shall

be at least 8 per cent, and others 9.3 per cent of solids not fat, as will be seen in the following table:

STATE STANDARDS FOR DAIRY PRODUCTS.

In force June, 1900. From Bull. 26, U. S. Dept. Agr., Bureau of Animal Industry.

	Milk.			Skim-Milk. Total solids, Per cent.	Cream. Fat, Per cent.
	Total solids, Per cent.	Solids not fat, Per cent.	Fat, Per cent.		
District of Columbia	....	9.0	3.5	9.3	20
Georgia	....	8.5	3.5		
Illinois [1]	12.0	....	3	....	15 [2]
Indiana	....	9	3		
Iowa	12.5	....	3.	....	15
Maine	12	....	3		
Massachusetts	13	9.3	3.7	9.3	
Massachusetts, Apr. and Sept.	12.5	9	3		
Michigan	12.5 Sp. gr. 1.029–33	....	3	Sp. gr. 1.032–37.	
Minnesota	13	....	3.5	....	20
New Hampshire	13				
New Jersey	12				
New York [3]	12	....	3		
North Dakota	12	....	3	....	15
Ohio [3]	12	....	3		
Ohio, May and June	11.5				
Oregon [3]	12	8	3	Sp. gr. 1.038....	20
Pennsylvania	12.5	....	3	2.5 p.c. fat, 6 p.c. cream by vol. sp. gr. 1.032–37.	
(Milk and skim-milk standards refer to cities of second and third classes.)	Sp. gr. 1.029–33				
Rhode Island	12	....	2.5		
South Carolina	....	8.5	3		
Utah	....	....	....	9 p. c. solids not fat.	
Vermont	12.5	9.25			
Vermont, May and June	12				
Washington	....	8	3		
Wisconsin	....	....	3	....	18

[1] Condensed milk shall be made from milk containing at least the legal standard of three per cent of butter fat and evaporated to one third or less of its original volume.

[2] Coffee cream shall contain at least fifteen per cent of fat and whipping cream twenty-two per cent fat.

[3] Milk solids of condensed milk shall be in quantity the equivalent of twelve per cent of milk solids in crude milk, of which twenty-five per cent shall be fat.

While many cows give milk below these standards (36), if found in the possession of an innocent dealer it is likely to be condemned as watered. It should be borne in mind that a great deal of milk that contains over three per cent of fat will not contain nine per cent solids not fat. This will be quickly seen if the percentage of fat is subtracted from percentages of total solids in analyses given in paragraph 38.

80. The complete analysis of milk is a complicated process and not adapted for general use. The methods of analysis adopted by the Association of Official Agricultural Chemists are generally used at the United States Agricultural Experiment Stations. It is well to follow these methods, as they represent the combined experience of the best chemists of America, and are modified whenever any improvements are worked out. They are published by the United States Government, and a copy can be had by sending five cents *in coin* to the Secretary of Agriculture, Washington, D. C.

Full description of methods used by Babcock, Russell, and Vivian in detection and separation of the natural enzymes of milk, and in the separations and estimation of the nitrogenous compounds of milk other than casein, will be found in the fourteenth, fifteenth, and sixteenth annual reports of the Wisconsin Agricultural Experiment Station. An account of the salts of casein and paracasein discovered by Van Slyke and Hart, and their methods of estimating the proteolytic compounds in milk will be found in the Tenth Annual Report, 1903, of the New York Agricultural Experiment Station (Geneva).

English methods of analysis will be found described in "Richmond's Dairy Chemistry" (Philadelphia, 1899).

It is interesting and instructive qualitatively to separate the proteids of cow's milk and breast milk for comparison. The following working directions are very satisfactory for this purpose:

Cow's Milk.

Dilute 10 c.c. of fresh cow's milk with 90 c.c. tepid water. Add about 1.5 c.c. of 10 per cent acetic acid and stir until a coarse precipitate forms. Allow to settle until supernatant liquid is clear. Filter. The precipitate consists of *casein acetates* and the fat of the milk.

Boil the filtrate until a flocculent precipitate forms. This is *albumin* of milk. Filter.

To the filtrate from the albumin add as much common salt as will dissolve. Then add 12 per cent aqueous solution of tannic acid until no further precipitation occurs. The precipitate consists of *albumoses* and *peptones*.

Breast Milk.

Dilute 10 c.c. of breast milk with 40 c.c. of tepid water, stir, and cautiously add 10 per cent acetic acid until signs of precipitation appear. Then allow to stand until precipitate settles. Then filter and proceed as with cow's milk for albumin, albumoses, and peptones.

There is a great difference between the behavior of cow's milk and breast milk with 10 per cent acetic acid. It will be nearly impossible to filter the casein from the breast milk and it may be necessary to boil the mixture before it can be filtered to determine the albumoses and peptone. In this case the albumin will be with the casein in the precipitate.

81. *Acidity of Milk* is never determined directly, but by the addition of some alkaline solution, the neutral

point being determined by a color indicator, phenophthalein being generally used for this purpose. Milk fresh from the cow is quite acid to phenolphthalein, but almost neutral to litmus. Heating fresh milk, which drives off the gases it contains and possibly precipitates the acid salts of calcium, reduces the acidity greatly, as the following figures of Smethan and Ashworth quoted by Richmond show:

Milk direct from the cow	26.7° acidity.
Milk direct from the cow, after boiling	12.2° "

Richmond recommends calculating as lactic acid the acidity to litmus, and gives as a reason the results from sour milk as follows:

	I.	II.	III.	IV.	V.
Acidity (to phenolphthalein)	1.24	1.89	1.82	1.52	1.32
Acidity (to litmus)	.65	1.14	1.28	.86	.56

82. For testing the acidity of milk decinormal alkali solutions are generally used, but as it is a delicate operation to make these, and as they deteriorate on standing, Storch and also Richmond recommend the use of lime-water, which is almost exactly one-twentieth normal and which does not deteriorate if kept for any length of time, provided some lime is left in the bottom of the bottle. As the bottle becomes empty, all that is necessary is to add more distilled or rain water.

Lime-Water.—Get from any grocery store an ounce or so of lime; add a pint of water, and stir thoroughly. Allow the undissolved lime to settle, and pour off the clear lime-water, which will contain any potassium or sodium that may have been present in the lime. Do this several times. Now pour on a quantity of distilled water,

depending on the sized bottle the lime-water is kept in, and cork; when the lime has settled so the water is clear, it is ready to be used and may be removed as wanted with a pipette, as will be described presently. Always have some undissolved lime at the bottom of the jar, as by this means the lime water is readily kept saturated. As fast as the lime water is used, add distilled water to take its place. It is well to use a fresh lump of lime every two or three months, as in time the sediment may consist of carbonate of lime, owing to absorption of carbonic acid from the air.

An easy way to test the acidity of milk is: (1) First mix the milk thoroughly, and (2) with a graduated 1 c.c. pipette, such as is used in measuring urine, or Fehling's sugar-test solution, place 1 c.c. of the milk in a small evaporating dish or test-tube. (3) To this add one drop of an alcoholic solution of phenolphthalein (1 gm. to 30 c.c. alcohol). (4) With another 1 c.c. pipette add drop by drop clear lime-water, and shake the tube to mix thoroughly, until the milk is colored a faint pink. Now note how many .1 c.c. of lime-water were used.

1 c.c.	milk and	phenolphthalein	colored by	0.1	c.c.	lime-water	.045 p.c. acid.
1 "	"	"	"	.2	"	"	.09 "
1 "	"	"	"	.3	"	"	.135 "
1 "	"	"	"	.4	"	"	.180 "
1 "	"	"	"	.5	"	"	.225 "
1 "	"	"	"	.6	"	"	.270 "
1 "	"	"	"	.7	"	"	.315 "
1 "	"	"	"	.8	"	"	.360 "
1 "	"	"	"	.9	"	"	.405 "
1 "	"	"	"	1.0	"	"	.450 "
1 "	"	"	"	1.1	"	"	.495 "
1 "	"	"	"	1.2	"	"	.540 "
1 "	"	"	"	1.3	"	"	.585 "
1 "	"	"	"	1.4	"	"	.630 "
1 "	"	"	"	1.5	"	"	.675 "

A simple rule is: Multiply 0.0045, the weight in grams of lactic acid neutralized by 1 c.c. lime-water, by the number of cubic centimetres of lime-water used, and divide by 100, which gives the percentage of acidity.

Farrington has devised an alkaline tablet for use in testing acidity of milk. One of these tablets, which also contains phenolphthalein, is to be dissolved in one ounce or 30 c.c. of distilled or rain water. If one volume of milk is faintly colored pink by an equal volume of this solution, it contains 1.1 per cent acid; colored by 2 volumes, 0.2 per cent acidity, and so on. These tablets, which are carried by many dairy supply houses, have recently been put up for use of physicians and families under the name of "ideal milk testers." Many of the wholesale druggists have them.

It should be remembered that these methods of determining acidity are only relatively correct. No exact method has been devised. Degrees of acidity, a term used in England, means the number of cubic centimetres of decinormal alkali needed to neutralize 100 c.c. of milk. Each degree corresponds to 0.009 per cent lactic acid.

It has been widely taught that breast milk is alkaline and that the addition of five per cent of lime water would render cow's milk alkaline. Kerley, Gieschen, and Myers made some comparative examinations of breast milk and cow's milk at the New York Infant Asylum, and found that not a single specimen of cow's milk took less than 55 per cent of lime water to render it alkaline, while "certified milk" and "laboratory milk" required from 70 per cent to 85 per cent of lime water to render them alkaline to phenolphthalein. They also found that it was necessary to

add 8 per cent to 24 per cent of lime water to breast milk to render it alkaline to phenolphthalein. In their examinations of milk, litmus paper was also used, and it was found that it was unreliable for testing milk, as one specimen of the paper would show breast milk to be alkaline, while another specimen would show the same milk to be neutral. Richmond states that the use of litmus paper has been abandoned in scientific examinations of milk. A large number of examinations of the "certified milk" used for infant feeding at the New York Post Graduate Hospital have been made, and this milk required from 70 per cent to 90 per cent of lime water to render it alkaline, although a few times it required but 50 per cent. It is found that the milk becomes thicker and more viscid in proportion to the amount of lime water required to render it alkaline, so there can be little doubt that some of the acidity of milk is due to the mucin of the milk, which is a weak acid that swells up after combining with the alkali.

83. *Preservatives* in milk are not uncommon, especially in summer, in country towns and small cities where milk is not inspected, and even in large cities some of the milk is not free from them. In another place (63) the composition of the principal preservatives now on the market is given, but as new preparations are likely to appear from time to time no detailed method of detecting each will be given, but one broad method that will cover them all; viz., place a few cubic centimetres of milk in a test-tube, plug with cotton, and keep it at a temperature about 80° to 90° F. This may be done by setting the tube in a cup of tepid water. If the milk does not sour or otherwise change in twenty-four hours, either the addi-

tion of preservatives or pasteurization should be suspected. Formaldehyde can readily be detected in making the Babcock milk test (75), or by mixing equal parts of milk and water in a test-tube and adding, so as to not mix, a little concentrated sulphuric acid. A violet ring at the junction of the acid and milk indicates formaldehyde. C. P. sulphuric acid will not answer unless a minute quantity of ferric chloride is added.

84. *Sterilized Milk* may be detected by first adding a starch and iodide-of-potassium solution, and then a drop or two of dilute peroxide of hydrogen. Milk heated above 175° F. remains unchanged; fresh milk or milk not heated to 175° F. is colored blue. This is Storch's test.

To make the test: Add 1 mgm. cornstarch to 200 c.c. water, and boil. Now add 5 mgm. potassium iodide and filter after the flocculent matter has settled.

To a mixture of one part of milk and two parts of the starch-iodide potassium solution, add one or two drops of a dilute (1 : 10) solution of peroxide of hydrogen. This test should be performed with fresh milk to get an idea of how it acts, before testing heated milk.

85. *Preservation of Samples of Milk.*—It is sometimes inconvenient to test a sample of milk for several days after it is obtained, or it may be necessary to send the sample away by mail or otherwise. In such cases add a few drops of formaldehyde and fill the bottle up to the cork, which should be tied in. If the bottle is not full the milk will churn and butter will form.

CHAPTER XV.

BACTERIOLOGICAL EXAMINATION OF MILK.*

In order that a bacteriological examination of milk may be made which shall have any significance as indicating the wholesomeness or unwholesomeness of milk, it is necessary to know at the outset as much as possible in regard to the relation of various milk bacteria to health. Upon this subject unfortunately we are as yet in considerable ignorance. The few facts which we know may be briefly summarized.

Diseases Attributed to Milk.

It is certain that some well-known diseases are occasionally distributed by milk.

86. *Tuberculosis.*—This disease is much more common in childhood than was believed a few years ago. It is a well-known fact that cows suffer quite largely from tuberculosis, and that the milk which such cows produce is sometimes contaminated with tubercle bacilli. It is generally believed that such milk, if used as a food by infants, may give rise to tuberculosis in the child. There is, however, at the present time a considerable difference of opinion as to the extent of the danger to the child from this source. Whereas some are quite convinced

* This chapter has been prepared by Prof. H. W. Conn, of Wesleyan University.

that the danger is very great and that a considerable portion of the infantile tuberculosis is attributable to milk, there are others that regard the danger as not very great. There seems to be sufficient evidence to prove that the child may acquire tuberculosis from this source, although we do not have, at present, sufficient evidence to indicate how great the danger may be. It is well to remember, however, that the tubercle bacillus does not multiply in the milk, and if the milk from one tuberculous cow is mixed with milk from a number of other healthy animals, the final product which is given to the child as food is quite likely to be diluted to such an extent that the tubercle bacilli, even though dangerous, are not present in sufficient numbers to produce much trouble.

87. *Typhoid Fever.* — Perhaps typhoid fever is the disease that has been most frequently distributed by milk. It is at all events the one in regard to which we have the greatest amount of evidence. The number of typhoid epidemics that have been positively traced to milk is now very great. There are scores of instances where a community suffers from an epidemic of typhoid of a more or less serious character, and where practically every case of the disease may be traced to milk from a certain source. An outbreak of a typhoid-fever epidemic in any community renders the milk suspicious, and the milk is the first point for investigation. The cow herself does not suffer from typhoid fever, and the typhoid bacilli which get into the milk must come from a different source subsequent to the time when the milk is drawn from the cow. This may be from a milker, who is recovering from or coming down with typhoid fever; it may be from the water of a

well which has become contaminated with typhoid dejecta, or it may be some other secondary source. As a rule, however, it is believed that the contamination is either from a typhoid patient, or some one who has in some way come in contact with a typhoid patient, or with typhoid contaminated water. Unlike the tubercle bacillus, the typhoid bacillus is capable of multiplying rapidly in milk. The result is that milk contaminated with typhoid bacilli is far more dangerous than milk contaminated with tubercle bacilli. A few organisms that find entrance at the outset have an opportunity of developing rapidly before the milk is consumed, and the consumer swallows milk that contains typhoid bacteria in perhaps very large numbers. The result is that the danger of typhoid from typhoid-contaminated milk is very great, and the typhoid epidemics from such a source are apt to be violent. It rarely does any immediate good to trace a typhoid epidemic to milk from a given source. The milk is contaminated usually only for a day or two, and by the time the epidemic has appeared and it has been possible to trace it to milk from a given source, the contamination at that source has long since passed, so that nothing further can be done to check the development of the epidemic in this direction. It is, of course, an advantage to introduce general sanitary precautions in the farm producing the milk, but no particular typhoid epidemic due to milk has been checked by the discovery of its source.

88. *Scarlet Fever and Diphtheria.*—These two diseases are occasionally distributed by the milk supply, although our knowledge in regard to them is at present

somewhat fragmentary. We do not positively know whether the cows themselves suffer from these diseases in such a way as to contaminate their milk with the bacteria in question. We do know, however, that milk may become contaminated with the infectious material of both of these diseases subsequent to the milking, and that sometimes such milk is the source of distribution of both of these diseases. The milk is, therefore, one of the factors to be guarded against in the case of epidemics of diphtheria and scarlet fever, but beyond such simple facts our knowledge upon this matter is rather scanty.

89. *Diarrhœal Diseases.*—In regard to the kind of bacteria which produce these difficulties, we are as yet in almost complete ignorance. There are quite a number of species of bacteria found in milk that have been demonstrated by bacteriologists to be capable of producing certain poisonous secretions as the result of their growth. If these bacteria should grow in abundance in milk or in the intestine of the child, it is quite certain that they would produce toxic products, and such products would naturally produce intestinal disturbances. It is also a fact that the intestinal contents of children suffering from such troubles show a variety of fermentative changes, a putrefaction of some sort being extremely common. It is therefore probable that it is some of the micro-organisms which produce putrefaction that are responsible, in considerable degree, for these intestinal troubles. But beyond some such general suggestions as these, our bacteriologists as yet are unable to make any very definite statements concerning the relation of bacteria to infantile intestinal disease.

Value of Bacterial Examination of Milk.

90. Recognizing these facts, the question arises as to whether a bacteriological examination of milk for the purpose of determining its healthful qualities is possible and practicable. A bacteriological examination of drinking-water has proved extremely useful as a means of assisting in determination of the healthfulness of drinking-water, although not in itself wholly satisfactory. It was quite natural that the methods of bacteriological examination which were first used in the study of water should be transferred directly to the study of milk. The examination of water has consisted in the past chiefly in determining the number of bacteria that are present in a cubic centimetre of water, and drawing a conclusion as to the suspicious nature of the water from the number of bacteria that are present in a cubic centimetre of water. In more recent years there has been a further attempt slightly to differentiate the species of bacteria that are found. This method of *quantitative* bacteriological analysis has also been applied to milk as a means of suggesting conclusions as to the healthfulness of milk. But when the method is applied it is found quite unsatisfactory, because the results obtained are totally different from those obtained in the study of water. So unlike are these results that the two problems appear to be wholly unlike.

In the first place, the number of bacteria found in milk is quite incomparable with that found in any samples of water. Whereas a sample of water containing a few thousand bacteria per cubic centimetre is immedi-

ately regarded as suspicious, it is a certain fact that many a sample of milk which is perfectly wholesome contains bacteria by hundreds of thousands and possibly by millions. A comparison of the number of bacteria in water and milk will show in water the presence of a few hundreds per cubic centimetre, and in milk the presence of many thousands, hundreds of thousands, or occasionally millions. Even when compared to sewage, from the standpoint of the number of bacteria, milk proves to be surprisingly bad. The milk that is supplied to our cities frequently contains *more bacteria than is present in the city's sewage*, and in the case of unusually bad samples of milk the number of bacteria outnumbers that which is found in the worst sewage.

Manifestly the interpretations of the numbers of bacteria as found in milk and in water cannot be the same. It is certainly not to be inferred that milk is a more unhealthful product than sewage because it contains a larger number of bacteria. The use of sewage as drinking-water would be disastrous, but milk that contains many more bacteria is used constantly without appreciable injury. The determination of the number of bacteria does not determine the wholesomeness of milk, and the interpretation of the results in the study of milk is quite different from their interpretation in the study of water. We cannot condemn a sample of milk upon the same bacteriological grounds as those which force us to condemn a sample of water.

The presence of small numbers of bacteria does not necessarily mean that the milk is wholesome, for among the small number there may be pathogenic forms which

are distinctly injurious. On the other hand, the presence of large numbers does not mean that the milk is necessarily unwholesome, for, if this large number of bacteria contains only harmless or useful forms, their presence is not detrimental. What, then, is the value of a counting of the number of bacteria in milk?

Bacteriologists have learned that the number of bacteria in any sample of milk is dependent upon two factors. First, care in the dairy. Second, the care in transportation and in using cleanly vessels and low temperatures. Milk produced in a dirty barn will contain larger numbers of bacteria than milk from a clean barn, and the same general fact is true in connection with the methods in transportation. Hence it is that the bacteria count will enable us to determine, with considerable degree of accuracy, the question of the cleanliness of the dairy from which the milk was originally derived, and the care which has been given the transportation of the milk. If it is found that milk contains bacteria in large numbers—several millions per cubic centimetre—by the time it is ready for distribution, the inference is drawn that it has been placed under conditions which should be condemned. Either the original dairy failed to pay proper attention to cleanliness, or those concerned in the transportation of the milk have been careless in their work. If, on the other hand, the milk is found to contain a small number of bacteria, the conclusions are that the conditions have been satisfactory.

Now, while it is true that milk that contains a small number of bacteria may perhaps contain pathogenic bacteria and thus be dangerous, nevertheless in the majority

of cases milk which has been so carefully handled that the number of bacteria has been kept low has not been brought into a condition where it is likely to be contaminated with pathogenic germs. Only the dairyman who takes care to protect his milk will be able to keep the bacteria reduced to low numbers, and such a dairyman is one also who will be quite sure to guard his milk from contamination by pathogenic bacteria. On the other hand, the presence of large numbers of bacteria suggests carelessness, and indicates, therefore, that there is a greater opportunity for the entrance into the milk of mischievous bacteria. Hence it is that while the presence of large numbers of bacteria does not necessarily mean that the milk is unwholesome, it renders us suspicious of conditions at its source and of the methods adopted in its transportation.

It is difficult, perhaps impossible, to fix upon any standard as to the number of bacteria which wholesome milk may contain. Should we condemn milk when it contains ten thousand, thirty thousand, one hundred thousand, or a million bacteria per cubic centimetre? The question cannot be answered, because the answer will depend upon conditions and, to a large extent, upon the season of the year. It is at present impracticable to insist upon any definite standard at any season of the year for the general milk supply. It is true that in some cities a bacteriological standard has been set for a certain class of milk. Sometimes this standard has been set at ten thousand per cubic centimetre, sometimes at thirty thousand per cubic centimetre. Such standards are practical only for special cases, and have been used only when

some special dairy or milk dealer wishes to furnish a special product and receive an advanced price for the same. It is useful for the general plan of producing "certified milk," mentioned elsewhere in this work. But for the general supply of a large city, no standard can be insisted upon at the present time, without excluding most of the milk in the summer season.

From all these facts it will follow that before a bacteriological examination of market milk can be satisfactory, it must be possible to do something more than determine simply the numbers of bacteria. Some method must be determined by which the different types of bacteria can be differentiated from each other, so that we may know how many of the suspicious organisms are present and how many are perfectly normal and probably wholesome. The question whether such a differentiation is possible has never been as yet thoroughly discussed, and hitherto no attempt has been made, in all of the bacteriological analyses of market milk, to separate the abnormal from the normal types, or to determine to what extent this immense number of micro-organisms may be perfectly wholesome and to what extent they are likely suspicious. Is such a differentiation possible?

Differentiation of Types of Milk Bacteria.

91. In the first place, we must notice that there is at present no practical possibility of detecting in milk the presence of the bacteria causing tuberculosis, scarlet and typhoid fevers, or diphtheria. The tubercle bacillus can be found in milk by proper tests, but the method is so difficult as to render it useless as a means of determining

the wholesomeness of milk. It has been hitherto quite impossible to detect typhoid bacilli in milk, and at present there seems to be no prospect of success in this line. The same is true in regard to the diphtheria bacillus, although the diphtheria bacillus may be detected in milk. The cause of scarlet fever is unknown, and there are thus no bacteriological methods as yet within our reach which enable us to detect in milk the bacteria which produce either of these four diseases. Inasmuch as we do not know positively the cause of the diarrhœal diseases, it is of course evident that bacteriological methods will not enable us to detect with any certainty whether the bacteria that produce them are present in milk or not. Hence it follows that bacteriological analysis of to-day will not enable us to detect satisfactorily the presence in milk of the exciting cause of any of the diseases most commonly distributed by milk.

Nevertheless a partial differentiation of the milk bacteria is quite feasible. To understand this it will be necessary to mention the chief types of bacteria which are found in normal milk, referring to their action upon milk and their probable relation to health. The number of species of bacteria present in milk is very great, and very little is known about the significance of most of them. We can, however, recognize among these bacteria three chief types which are readily distinguished from each other, and which probably have quite a different relation to the problems of the healthfulness of milk.

92. (1) *Lactic Bacteria.*—These are the most common bacteria in milk which is a few hours old, although in freshly drawn milk they are frequently not very numer-

ous. There are several types of lactic bacteria, differing from each other in more or less important particulars. In milk in the United States there are three or four species which are particularly common and may be regarded as lactic bacteria *par excellence.* The chief of these, B. acidi lactici, is found widely distributed, not only in the different parts of the United States, but also in the countries of Europe.

In their action upon milk these bacteria prove very troublesome, since they cause its *souring* and *acid curdling* (37). To keep the milk sweet it is therefore desirable that their numbers should be kept as low as possible. As relates to their influence upon the wholesomeness of milk, however, it seems quite probable that they are not detrimental (52). Milk which does not contain lactic bacteria is liable to varied putrefactive fermentations, which are prevented by the development of the lactic-acid bacteria. Moreover, there are reasons for believing that their presence in the intestine is advantageous rather than detrimental. At all events there is no evidence to indicate that the normal lactic bacteria render the milk unwholesome. Milk with a moderate number of lactic bacteria is probably less liable to produce intestinal disturbances than milk which contains other types of bacteria and no lactic organisms. The presence of lactic bacteria, therefore, will suggest a speedy souring of the milk, but will not give any suspicion as to its being unwholesome as a food.

93. (2) *Bacteria Producing Albuminoid Decomposition.*—The decomposition of albuminoid bodies frequently gives rise to putrefactive products. We know

nothing positive as yet as to the effect of such decomposition products in our foods, although it is known that some of the products arising from such decomposition are toxic in nature. It would seem most probable that the products of albuminoid putrefaction will be unwholesome either in the food we eat, or in the milk we drink, or in the intestinal contents. Whether the intestinal disturbances which are common in warm weather are due to such bacteria, and whether the summer troubles attributed to milk are traceable to such organisms, is not known. It is quite certain, however, that numerous putrefactive bacteria present in milk would render it at least suspicious. Milk containing many such bacteria will be more suspicious than milk with a much larger number of lactic bacteria. If it is possible by a bacteriological study of a sample of milk to detect the proportion of such putrefactive bacteria, it will give data which are of significance in the conclusions as to the wholesomeness of milk.

94. (3) *Bacteria with No Noticeable Action on Milk.* —These bacteria have apparently nothing to do with the keeping properties of the milk, and may be present in large numbers without producing any noticeable effect. Whether they are concerned in rendering the milk unhealthful cannot yet be stated. Probably some of them are, and if present in considerable numbers may render the milk unwholesome. Among these the most prominent is a variety of coccus forms, which belong to the genus *Streptococcus*. These are almost universally present in milk. They come in part from the milk ducts (55), and it is almost impossible to draw milk without them. Their number is sometimes very great, and sometimes

small. Their significance in determining the healthfulness of milk cannot as yet be stated.

95. It is possible by a simple modification of the common bacteriological methods of analysis to study milk in such a way as to differentiate these three types of bacteria from each other. While such a differentiation will not, in the present state of our knowledge, be sufficient to determine accurately as to the wholesomeness of milk, it will bring us much closer to that end than the method of simply counting of numbers, and will frequently show whether, in the case of badly contaminated milk, the trouble is in the improper conditions of the original barn and in uncleanliness in milking, or due to improper handling of milk subsequently to the milking.

96. If milk is retained at a moderate temperature for quite a number of hours, the lactic bacteria commonly grow rapidly and soon come to outnumber all the other species put together. In fresh milk it is rare that the lactic bacteria are very numerous. Hence it follows that if a sample of market milk is examined and found to contain a large per cent of lactic bacteria of the common kind, it is due to the fact that the milk has been kept moderately warm for a number of hours. If the milk is kept cool the lactic bacteria do not thus grow, and remain for a long time in small relative numbers. The presence of great numbers of lactic bacteria, therefore, suggests insufficient cooling of the milk and perhaps greater age.

If, on the other hand, the milk shows large numbers of miscellaneous bacteria, either of the putrefactive type or of those having no effect on the milk, the inference to be

drawn is different. Under these conditions we are led to suspect a greater primary contamination of milk during the milking. If there is much filth in the barn and around the cow, the milk is likely to be contaminated with a large variety of bacteria. Hence milk which shows such variety suggests lack of proper conditions in the barn. Thus the relative abundance of lactic and other bacteria in a sample of milk may give data for concluding whether the milk was badly contaminated at the start, or whether it has simply been kept at too high a temperature so as to stimulate the growth of lactic bacteria. That there is a practical advantage in such a knowledge will be evident at once.

Directions for Bacteriological Examination of Milk.

97. In order to make a bacteriological study of milk it is necessary to have a previous knowledge of ordinary methods of laboratory work. It is assumed, therefore, that those who wish to use the following method have a previous knowledge of making and using culture media, and only such points will be explained in detail as contain modifications of the common laboratory methods.

Culture Medium No. 1.—Litmus sugar gelatin.

1.	Water	500 c.c.
	Peptone	10 gm.
	Milk sugar	30 "
	Gelatin	120 "
	Liebig's extract of beef	5 "

These materials are placed together in a dish and dissolved by heating, at a temperature below 60° C., to make a solution which, as will be seen, contains twice the quan-

tity of the various ingredients that is contained in the ordinary gelatin culture media. After the material has become thoroughly dissolved the solution is neutralized. For neutralization is used a solution of NaOH, and the neutral point is determined by litmus paper. A weak solution of NaOH is added until the material is in the very faintest degree alkaline. In other words, since the solution is at first acid, just enough NaOH is added to pass the neutral point, as shown by its action upon red and blue litmus paper. After the neutralization the white of an egg is added and the whole is boiled for three-quarters of an hour.

2.	Water..	500 c.c.
	Dry litmus (in cubes)	48 gm.

The litmus is steeped in the water for three hours or more, at a temperature of about 60° C., to dissolve as much of the active material as possible. The solution is then filtered.

After solution 1 has boiled with the white of an egg for three-quarters of an hour, it is mixed with the filtered litmus solution No. 2, the two together making the bulk up to about a litre, and water is added if necessary to replace evaporation. The solution is then warmed slightly, though not above 60°, in order to avoid as much as possible the changes in the litmus which high temperatures produce. It is then filtered through absorbent cotton, distributed in sterilized tubes, about 8 c.c. in each, and is ready for final sterilization. The sterilizing is carried on as usual by steaming on three successive days. The sterilization always has a tendency to change the color of the litmus to a reddish brown, but the blue is restored after

the litmus cools and stands for a few hours in contact with the air. When finally sterilized and cooled the solution should be a deep blue color, so deep a blue that when poured out in Petri dishes the color is quite strong. The litmus of commerce is quite variable in strength, three per cent of litmus (30 gm.) being sometimes sufficient to give the required blue color, while other lots of litmus require 40-50 gm. As a rule 48 gm. to the litre produces as good a color as can be desired, but sometimes, if the litmus is exceptionally strong, a smaller amount is preferable. It is advantageous to buy the dry litmus in rather large quantities, and then after a single experiment has shown the amount of litmus of the particular sample that is needed to produce the desired color, the same percentage of litmus is employed until the whole quantity of litmus has been used. A new sample of litmus will require a new percentage.

Culture Medium No. 2.—Litmus Sugar Agar.—This medium is prepared in exactly the same way as was the gelatin culture medium, except that one and one-half per cent of agar is added instead of twelve per cent of gelatin. The other methods of procedure are the same.

98. In the use of these media for the analysis of the milk, the first thing that is to be done is to determine upon the proper dilution of the milk which will give the most satisfactory results. Milk contains so many bacteria that is never possible to use as much as 1 c.c. of milk in a single test, as is commonly done in water testing. The milk must therefore be diluted with sterilized water. The question of determining the amount of dilution is one of the most difficult points connected with the whole

testing, from the fact that different samples of milk require different dilutions for proper study. The dilution should be such that the plates which are subsequently made should contain from one hundred to three hundred colonies of bacteria. The extent of the dilution of the milk necessary to produce this result varies with the age of the milk, with the temperature, and with the season. We have found in winter weather that a dilution from two hundred to six hundred times is ordinarily most satisfactory. In summer weather the dilution should be higher. From one thousand to five thousand dilutions are necessary if the milk is somewhat old or during warm weather. The determination of the proper dilution requires some degree of judgment and experience, and it is always best to use more than one dilution for each experiment, in order that the best results should be obtained.

Method of Procedure.

99. Sterilize a number of small flasks which are marked in some way (best by being etched) at the 99 c.c. point. Sterilize also a number of small vials, some of which are marked at the 5 c.c. point, and others at 19 c.c. These vials should be provided with corks, which are laid loosely in the mouth during sterilization, but placed in tightly after sterilization. Sterilize a litre or more of water in an autoclave under steam pressure in the ordinary manner.

At the beginning of an experiment fill one of the flasks to the 99 c.c. point with sterilized water, and fill one of each sized vial to its mark in the same way. One cubic centimetre of the milk is taken from the milk to be

tested in a sterilized 1 c.c. pipette, and placed in the flask with the 99 c.c. of water; this dilutes it one hundred times. One cubic centimetre of this mixture is then placed in one of the vials, in the 5 c.c. vial if the dilution desired is to be six hundred, and in the 19 c.c. vial if the dilution is to be two thousand.

Meantime a number of tubes of the litmus gelatin and one or two tubes of litmus agar have been melted. There is now taken from the flask containing the 100 c.c. milk dilution one-half of a cubic centimetre with a sterilized pipette, and this is mixed with one of the tubes of gelatin. This, after being thoroughly mixed in the gelatin by a gentle but thorough shaking, is poured into a Petri dish and allowed to harden. It is best to make at least three such inoculations, each containing one-half of a cubic centimetre of the liquid in the flask. These are then labelled as diluted two hundred times. To obtain the dilution of six hundred times, 1 c.c. of the mixture in the small vial is removed by a sterilized pipette, and as before mixed with the gelatin in the gelatin tubes and poured out into Petri dishes. At least three such plates should be prepared from this dilution, and these must be labelled as diluted six hundred times. If the higher dilution is required, 1 c.c. of milk from the first flasks of 100 c.c. is to be put into the vial containing 19 c.c. of water. This will dilute the original milk two thousand times, and 1 c.c. of this is mixed with a tube of gelatin and poured out in Petri dishes as usual and labelled as diluted two thousand times. To obtain a dilution of four thousand times, one-half a cubic centimetre from the vial is mixed with a tube of gelatin.

From each sample of milk there should be made at least six plates, with two different dilutions. It is desirable also to make at the same time two plates with the agar culture medium, for reasons to be mentioned presently. For this purpose 1 c.c. of the mixture diluted six hundred times is placed in a tube of agar culture medium No. 2, mixed thoroughly, and poured out in a Petri dish. There will thus be prepared for each experiment eight plates, three of which are made with a dilution of two hundred or two thousand in gelatin, and three in a dilution of six hundred or four thousand in gelatin, and two in agar. These plates are then set aside at ordinary temperature to grow.

Study of Plates.

100. In the study of the plates it is always necessary to allow the plates to grow for three or four days if possible. The reason for this is that not until the fourth day do the different colonies become so well developed as to be distinguishable from each other. The great difficulty of the whole method consists in the fact that it sometimes happens that the milk contains many liquefying bacteria which grow rapidly and liquefy the gelatin. If the gelatin begins to liquefy rapidly it is necessary to study the plates at once in spite of the fact that the differentiation is not perfect. If, however, the liquefying bacteria are not numerous and do not grow rapidly, the plates may be kept for four or five or even more days before they are studied. The longer the plates grow the better the differentiation which is obtained.

At best, however, the presence of liquefying bacteria

will make it impossible properly to differentiate the bacteria in a considerable number of the samples of milk, and sometimes they are so numerous as to make it even impossible to determine the numbers of the colonies, to say nothing of determining the varieties. For this reason the two agar plates are introduced in the experiment; the agar plates, not being liquefied, will serve as a test upon which we can fall back if the gelatin plates become ruined by the growth of liquefiers. The agar plate is not so satisfactory as the gelatin plate, and is to be used only when the gelatin plates prove unsatisfactory because of liquefiers.

In the study of the colonies on the plates, after they have satisfactorily grown, several points are to be determined:

1. The total number of bacteria. These are counted by the ordinary methods.

2. The number of acid-producing bacteria. These can be easily detected from the fact that each acid colony will be surrounded by a little red halo where the acid colony has turned the blue litmus red. This detection of the acid bacteria is also possible on the agar.

3. The number of liquefying colonies is to be counted. This is especially important, inasmuch as the liquefying colonies commonly represent the putrefactive organisms, and their relative abundance in milk is a matter of importance.

4. The number of bacteria producing no reaction in the gelatin or an alkaline reaction, and which do not liquefy, is to be counted. This is very easy to do, provided the plates have been properly diluted and have

grown sufficiently. Where it is necessary to study the plates early because of the abundance of liquefiers, the distinction between the acid bacteria and those producing no reaction is less sharp and not always satisfactory.

The results which are obtained should then be tabulated, and each table should be a double one. First, there should be given the *total number* of each type of bacteria detected; and second, the *percentage* of each type. The purpose of the latter is to show the relative preponderance of the different micro-organisms. The advantage of this is considerable. It has been found by many experiments that usually, when milk becomes a number of hours old, the bacteria increase rapidly, but the large percentage of the numbers present are lactic bacteria. If the milk shows large numbers of bacteria, and of this large number the great proportion are lactic organisms, the milk must be regarded as normal, though rather old. If, on the other hand, the results should show large numbers and a large percentage of liquefiers, or a large percentage of the non-acid bacteria, the milk must be regarded as possibly more suspicious. Examples of the tests of two samples of milk in this manner will be given as follows in the way of illustration:

No. 1.

	Total.	Lactic bacteria.	Liquefiers.	Miscellaneous.
Number of bacteria per c.c.	6,820,000	6,324,000	68,000	428,000
Percentage	....	93	1	6

No. 2.

Number of bacteria per c.c.	17,000	500	5,300	11,200
Percentage	....	2.8	31	66.2

Of these two samples it will be seen that the first contains many more bacteria than the second, but the percentage of lactic bacteria is much greater. The second sample contains small numbers, but with a very small per cent of lactic bacteria. The second sample of milk is doubtless fresh, but the first is a perfectly normal milk and not suspicious in spite of its large numbers. If No. 1 with its high numbers had had large percentages in the third and fourth columns, it would have been suspicious.

This method of testing milk is not given here as by any means complete, nor is it assumed that the results obtained will enable us to determine positively the wholesomeness of milk. Such a method of bacteriological study is, however, an advance over the practice of simply counting the numbers, which has been the common method of the past.

CHAPTER XVI.

CEREALS AND VEGETABLE FOODS.

NEXT to milk, cereals are the most important articles of diet, especially for older infants and young children. These all contain more or less fat, protein, carbohydrates (starch), and mineral matter; but these ingredients are stored up in cells composed of cellulose. Cotton fibre or paper is almost pure cellulose. While the herbivorous animals can digest large quantities of this cellulose, as their digestive tracts are specially adapted for this purpose (6), human beings cannot digest it except to a very limited extent. To enable the human digestive juice to *get at* the nutritious portions, vegetable foods must be cooked, which process ruptures the cells and allows the digestive juices to enter and dissolve their contents.

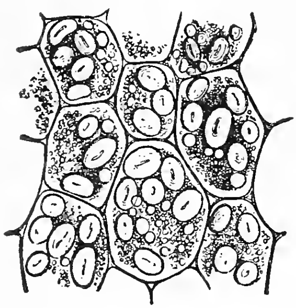


FIG. 43.—Showing Cells Containing Finely Divided Protein Matter Intermingled with Starch Grains. (Goodale.)

101. The protein of plants assumes many forms, the same as in animal tissues. Instead of multiplying the weight of nitrogen of cereals by 6.25, as has been usually done in determining the weight of protein, new factors are being used, as will appear farther on.

The proteids of wheat flour (N × 5.70) are composed of*:

	Per cent.	
Albumin,	0.3	—soluble in water; coagulable by heat.
Globulin,	.9	" dilute salt solution; coagulable by heat.
Proteose body,	.2	" water.
Gliadin,	6.8	" dilute alcohol.
Glutein,	4.5	—insoluble in water, salt solution, and dilute alcohol.
	12.7	

The proteids of barley (N × 5.68) consist of*:

Soluble proteid.	Leucosin	0.30	per cent.
	Hordein	4.00	"
	Edestin proteose	1.95	"
Insoluble proteid		4.50	"
		10.75	"

Oats are said to contain three principal forms of proteid, making a total of about fourteen per cent. Their weight is determined by N × 6.10.

102. When most vegetable substances are boiled with water, the heat and moisture combined cause the contents

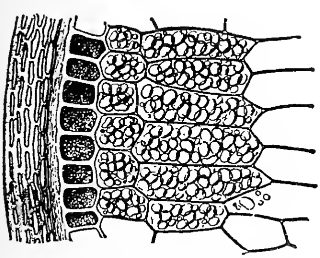


FIG. 44.—Wheat Grain Showing Cells Containing Starch Granules. (Goodale.)

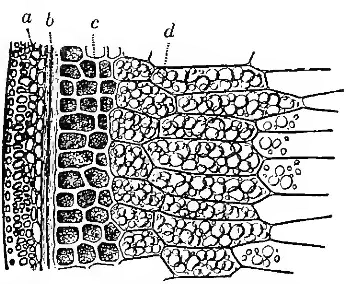


FIG. 45.—Barley Grain. *a*, Chaff; *b*, adherent cellular layer; *d*, starch granules. (Goodale.)

of the cells, particularly the starch grains, to swell up and break open the cells.

The rapidity with which this process takes place depends largely on the nature of the substance to be cooked

* Bull. 13, Part 9, Div. Chemistry, United States Dept. Agriculture.

and its physical condition. Potatoes, being very watery, swell up and burst as soon as the temperature reaches near the boiling point of water.

Whole cereals are hard and dry and have an outer coat that is almost waterproof, and even when placed in water it is some time before the cereals soften. If the whole cereals are brought to a boil, the starch in the outer cells swell up and the proteid coagulates, thus forming a coating which protects the interior of the grains from moisture. It takes many hours of boiling to disintegrate such cereals; but, if the cereals are first ground in a mill, to rupture the cells, and then boiled in water, the swelling up and bursting of the starch grains takes place in a few minutes.

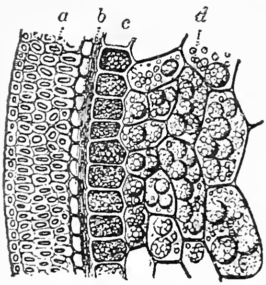


FIG. 46.—Oat Grain. *d*, Starch granules. (Goodale.)

There are a great many so-called "steam cooked" cereal breakfast foods on the market, which have been partially ground, that it is claimed require but a few minutes' cooking, but many of them will bear an hour's boiling with great advantage to the user. When they are thoroughly cooked, all trace of the original grain should have disappeared, or they should at least be very soft.

A general idea of the composition of such foods may be had from the following analyses of some of those best known. It will be noticed that there is very little difference between any of them of the same class. The claim that some of these foods are equivalent to ten times their weight of meat, wheat, oats, or other such food, should

not be believed, and the use of foods for which such extravagant claims are made should be discouraged. As a rule, these foods are very well digested and absorbed if properly prepared.

	Moisture.	Proteid.	Ether extract (Fat).	Carbohydrates other than fibre.	Crude Fibre.	Ash.
Corn Products.		N × 6.25				
Pearl Hominy *	13.05	8.31	0.60	77.62	0.63	0.42
Pearl Samp *	11.43	8.25	.81	79.26	1.03	.25
Oat Products.		N × 6.31				
Hornby's steam cooked oatmeal *	8.92	16.22	6.89	66.16	1.11	1.82
Quaker Oats *	7.86	16.22	8.23	66.07	1.25	1.62
Wheat Products.		N × ?		Carbohydrates.		
Cream of Wheat †	12.00	8.10	.90	78.70	....	.40
		N × 5.70		Carbohydrates not fibre.		
Germea *	10.28	7.98	1.88	78.68	1.17	1.18
		N × ?		Carbohydrates.		
Pettijohn's Breakfast Food †	10.70	11.90	1.80	73.90	....	1.70
Pillsbury's Vitos †	9 30	11.19	1.50	76.60	....	.70
Shredded Whole Wheat Biscuit †	10.80	10.60	1.50	75.60	....	1.50
		N × 5.70		Carbohydrates not fibre.		
Wheatena *	9.65	12.26	3.45	73.10	1.39	1.54
		N × 5.70				
Wheatlet *	11.78	10.38	1.51	75.21	1.08	1.12
Miscellaneous.		N × ?		Carbohydrates.		
Cook's Flaked Rice †	11.40	7.90	1.00	80.20	....	0.40
		N × ?				
Grape Nuts †	5.30	11.70	1.10	79.70	....	2.30
		N × ?				
Malt Breakfast Food †	8.00	13.40	2.20	75.00	....	1.40
		N × ?				
Whole Wheat Gluten †	11.20	15.90	4.60	65.60	....	2.70
		N × 6.25		Carbohydrates not fibre.		
Health Food Co.'s Cooked Gluten *	6.81	12.75	.71	79.96	.85	1.01
		N × 6.25				
Kingsford Oswego Corn Starch *	11.65	.44	....	87.48	.23	.23
Durkee's Pearl Tapioca *	11.46	.38	.09	87.95	.09	.12
Johnson's Gluten Flour No. 6 ‡	9.43	33.44	2.00	49.22	1.17	0.51
Johnson's Washed Gluten No. 7 ‡	7.62	75.44	1.33	7.81	0.75	0.58

* Bull. No. 13, Part 9, Div. of Chemistry, United States Dept. Agriculture.

† Bull. No. 55, Maine Agricultural Experiment Station.

‡ New Hampshire Sanitary Bulletin, October, 1903.

Dried beans and peas are very rich in protein, but as usually cooked, forty to forty-seven per cent of this is unabsorbed, and the toughness of the cellulose renders them unsuitable for a steady diet. However, when made into soup, beans and peas may be used quite freely with advantage after infancy.

Composition.	Water.	Protein.	Fat.	Carbo-hydrates.	Ash.	Authority.
Dried lima beans......	10.4	18.1	1.5	65.9	4.1	Atwater.
Dried peas	9.5	24.6	1.0	62.0	2.9	"

103. Long before children are old enough to eat these familiar foods, cereals can be and should be used when properly prepared and given with discretion. In the section on "Practical Infant Feeding" (133) the methods of using cereals will be found, but a rather detailed account of the principles involved in preparing them will be given here.

Cereals are composed principally of stored-up food for the plant germs which they contain. These germs have

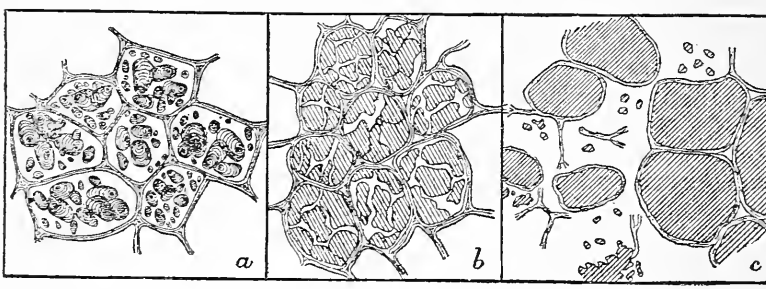


FIG. 47.--Showing Bursting of Starch Grains during Cooking. (Langworthy.)

the power to secrete enzymes (11), which dissolve nearly all of this reserve food, that nourishes the little plant until its roots have obtained a hold in the ground and its leaves are above the soil. The enzymes produce for the

plant germ, as nearly as is known, the same changes in the starch and protein of the cereals as do the digestive juices of human beings. These enzymes, or diastases, have different properties; some will simply dissolve the cellulose, others will liquefy the starches, and still others convert them into dextrin and maltose. The enzymes that dissolve the proteids of cereals are not of great importance in preparing cereals for infants.

By taking advantage of this knowledge (1) cereals can be rendered almost perfectly assimilable by the youngest infant with little or no digestive effort on its part; (2) or the starch of the cereal may be simply rendered soluble (137). This is the principle on which Baron Liebig prepared his infant food.

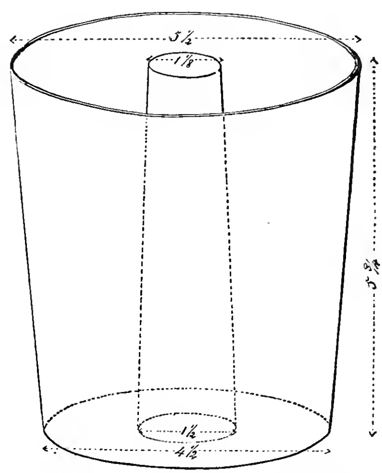


FIG. 48.—Tin Pudding-Bag or Rice Mould.

104. Another process of converting starch into dextrin and maltose consists of heating it uniformly to about 400° F. The starch grains do not lose their shape, but become soluble and lose their chemical properties. An old process of preparing wheat flour for infants and invalids consists in placing several pounds of flour in a cloth bag, and this in a kettle of boiling water and boiling for several hours. The bag is then removed and the doughy coating of the mass removed and a "flour ball" remains. A much simpler method is to put the flour in a "tin pudding bag," or rice mould, and boil for an hour.

The tube in the centre of the tin enables the flour to become heated quite rapidly, and if the kettle in which the boiling is done is kept covered the temperature of the flour will rise to above 200° F., but not quite to 212° F. This "baked flour" has a slightly yellow color and it is often said to be "dextrinized," or that the starch in it has been converted into dextrin. As a matter of fact, none or very little of the starch is converted into dextrin, as this process does not take place until the heat is raised to about 400° F. The change in this "baked flour" or "flour ball" lies in the *coagulation of the proteids*. If the baked flour is mixed with cold water, it will not form a dough or even lumps, but will settle out like raw starch. When mixed with water and boiled, there is no soluble proteid to coagulate around the starch grains and prevent their swelling up and bursting. In this point "baked flour" has a slight advantage over raw flour, but it is not so digestible as raw flour unless made into gruels, as will be explained in the next paragraph.

FIG. 49.—Appearance of Starch Grains in Bread from Flour Ground in Dreef's Mill; magnified 110 diameters. (Reduced one-third; Bull. No. 67, U. S. D. A. Office, Exper. Sta.)

105. From the foregoing it might be inferred that there is no advantage in baking bread or crackers as far as change of the starch goes, but this is an error. When flour is mixed with tepid water, there commences to be a conversion of starch into sugar that is caused by enzymes

natural to the flour, but which are destroyed in the baking process. During the process of making bread about six per cent of the starch is converted into sugar by these enzymes. The object of adding yeast to bread dough is to cause the formation of gas, which, as it expands, renders the gluten in which the starch grains are embedded porous and spongy. The heat of baking coagulates the gluten and other coagulable proteids and drives off the

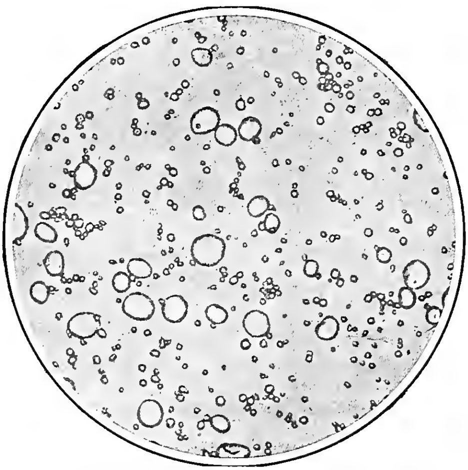


Fig. 50.—Wheat Starch; magnified 160 diameters. (Bull. No. 13, Div. of Chem., U. S. D. A.)

gas; the result is a porous food which exposes an immense surface to the digestive juices. Few cereals contain as much gluten as wheat, and consequently are not so well adapted for bread-making.

While the starch of baked flour is not in a condition to be easily digested, that of bread and crackers is readily digested. There are two reasons for this: (1) the action of the natural enzymes of the flour on the starch in the dough before baking, and (2) the effect of the heat on the

wet starch in the dough, which causes the starch grains to break open. The *crust* of bread may contain a small quantity of dextrin produced by heat, but none is formed in the interior of the loaf, as there the temperature never exceeds 212° F.

106. In selecting bread there is little or no advantage in choosing "whole-wheat bread" or Graham bread on account of their containing more mineral matter than ordinary bread, for digestion experiments have shown that owing to the greater quantity of cellulose in these breads absorption is not so complete as with white bread.

REPRESENTATIVE ANALYSES OF BREAD.*

	Water.	Protein.	Fat.	Carbohydrates	Ash.
White bread	36.06	8.78	1.73	52.73	0.70
Graham bread	41.92	8.24	1.05	46.85	1.94
Entire wheat bread	38.34	9.43	2.62	48.21	1.40

REPRESENTATIVE ANALYSES OF CRACKERS AND BISCUITS.†

	Water.	Proteids.	Ether ext. (Fat.)	Crude fibre.	Ash.	Salt.	Carbo-hydrates.
		N × 5.70					
Animal crackers	5.42	8.44	8.37	0.48	0.65	0.04	77.12
Butter crackers	9.48	10.21	8.79	.27	2.51	2.25	69.01
Cream crackers	4.28	9.01	13.77	.80	1.38	.53	71.56
Graham crackers	5.24	7.52	12.04	.59	1.18	.35	74.02
Graham wafers	3.14	6.79	10.87	....	1.42	.29	77.78
Lunch milk biscuits	8.87	8.15	12.47	.37	1.15	.37	69.36
Nursery biscuits	6.72	8.72	3.54	.42	.62	.08	80.40
Oat cakes	7.83	11.97	8.54	1.86	2.33	.05	69.33
Oyster crackers	6.51	10.21	9.19	.21	3.07	2.27	71.02
Pilot biscuits	8.18	9.52	10.22	.27	.91	.40	71.17
Saltines	6.70	10.21	12.68	.34	2.26	1.74	68.86
Sea Foam wafers	7.53	9.07	10.17	.39	1.44	.98	71.79
Soda crackers	8.43	8.89	7.68	.25	2.04	1.28	72.96
Water crackers	6.58	10.83	.21	.29	.49	.02	81.89
Zwieback	7.73	9.40	9.12	.30	.83	.20	72.92

* Bull. No. 85, United States Dept. of Agric., office of Exper. Stations.
† Bull. No. 13, Part 9, United States Dept. Agric., Div. of Chemistry.

CHAPTER XVII.

PROPRIETARY INFANT FOODS.

THESE foods are largely made from wheat flour, to which may have been added a small quantity of milk, beef extract, or sugar.

In the foods that are to be dissolved in water the starch has been converted into dextrin and maltose by the action of diastase, the starch-digesting enzyme of plants (103); and in the foods that are to be cooked, the flour has been baked, as can be done at home by the use of the "tin pudding bag" (104), hence the principles used in their manufacture are the same as those explained in the previous chapter.

From a *nutritional* standpoint these foods by themselves are almost without exception inferior to the best grades of condensed milk. When used with cow's milk, however, many of them are effective diluents, especially those containing baked flour. In cases of indigestion they sometimes prove helpful, but as a steady diet for an infant they should not be used unless along with a liberal amount of fresh milk.

Analyses of those foods that are said to have the largest sale are here given, with analyses of condensed whole and skim milk, and wheat flour. It will be noticed that many of the foods contain not much more fat than condensed skim milk. Fat is a very important food element

when derived from *milk*, as it then contains lecithin, one of the nerve-building elements. Whenever it is possible, an infant should have a sufficient quantity of fat from fresh milk.

	Moisture.	Fat.	Proteids.	Carbohydrates.	Ash.	Crude fibre.
Condensed whole milk (sweetened) *	24.06	11.28	9.36	52.28	2.13	
Condensed skim milk *	29.23	.64	10.73	55.69	2.63	
Wheat flour †	12.28	Ether ext. 1.30	10.18	75.63	.61	0.28

Proprietary Infant Foods which have Principal Sale in New York.

Class I. To be used with water; no cooking required.

Allenbury's Foods Nos. 1 and 2. Cereal Milk, Malted Milk, Milkine. These foods are said to be prepared by mixing a certain amount of sugar, or dextrin and maltose, derived from the starch of wheat flour with milk and drying.

Analyses to represent this class: ‡

	Moisture.	Fat.	Proteids.	Soluble carbohydrates.	Insoluble carbohydrates.	Ash.
Allenbury's Food No. 1 §	5.7	14.00	N × 5.7 9 7	66.85	....	3.75
Allenbury's Food No. 2 §	3.9	12.30	9.2	72.10	....	3.50
Malted Milk ‖	2.55	1.41	N × 6.25 14.00	63.87	15.68	3.57

* Richmond's "Dairy Chemistry."

† Bull. 13, Part 9, Div. of Chemistry, U. S. Department Agriculture.

‡ See first note on page 173.

§ Hutchinson: "Food and the Principles of Dietetics."

‖ Bull. 59, Laboratory of the Inland Revenue Department, Canada.

Class II. To be used with water; cooking required. These foods are said to be prepared by adding to some dried milk, sugar, and baked wheat flour. The cooking with water is to rupture the starch grains.

Analysis to represent this class*:

NESTLÉ'S MILK FOOD.†

Moisture	2.18	Soluble carbohydrates	43.84
Fat	4.45	Insoluble " (starch)	35.34
Proteids	10.72	Ash	1.60

Class III. To be used with milk; no cooking required.

These foods are said to be made from wheat flour by converting the starch into dextrin and maltose by diastatic action (103).

Analysis to represent this class:*

MELLIN'S FOOD.†

Moisture	4.72	Soluble carbohydrates	82.06
Fat	.30	Insoluble carbohydrates	....
Proteids, $N \times 6.25$	10.10	Ash	3.50

This food often gives good results by acting as an effective attenuant of the curd of cow's milk to which it is added.

Class IV. To be used with milk; cooking required.

Carnrick's Soluble Food, Eskay's Food, Health Food Company's Barley, Hubbel's Prepared Wheat, Imperial Granum, Ridge's Food, Robinson's Patent Barley. With the exception of Carnrick's Food these are said to be principally made up of baked wheat or barley flours.

* It is impossible to give the composition of the food as it will be in the infant's feeding bottle, as this will depend on the dilution of the food and the quantity of milk that is added to it.

† Bull. 59, Laboratory of the Inland Revenue Department, Canada.

Analyses to represent this class*:

	Moist-ure.	Fat.	Proteids.	Soluble carbo-hydrates.	Insoluble carbo-hydrates.	Ash.
Carnrick's soluble food †	5.69	2.18	N × 6.25 16.60	38.21	34.54	2.78
Imperial Granum †	6.04	.72	N × 6.25 13.77	3.94	67.46	.49
Ridge's Food †	8.12	.48	N × 6.25 13.83	5.02	69.24	.53
Health Food Co.'s Barley ‡..	10.92	.89	N × 5.82 6.98	?	80.35	.86
Robinson's Patent Barley †..	9.41	.41	N × 6.25 7.46	2.91	78.66	.94

These foods often form effective, though expensive, diluents of ordinary cow's milk.

* See first note on page 173.

† Bull. 59, Laboratory of the Inland Revenue Department, Canada.

‡ Bull. 13, Part 9, Div. of Chemistry, U. S. Department Agriculture.

CHAPTER XVIII.

MEATS AND EGGS.

Scraped Beef—Beef Juice—Beef Extracts and Teas—Meat Broths and Soups—Eggs.

107. Meats play but a small part in infant feeding, yet there is a great deal of misapprehension as to their value.

It is impossible to give the composition of meat, as it varies greatly with the cut. However, in a general way it consists of:

Water	50 to 75 per cent.
Protein	15 to 20 "
Fat	15 to 20 "
Mineral matter	1 to 3 "

The protein or proteid of meat is a mixture of several protein bodies, some soluble in water and salt solution and coagulable by heat (albumins and globulins), and others insoluble. A detailed account of these proteids will be found in Chapter III. About the only attempt to separate the proteids of meat in infant feeding is in preparing scraped beef, or beef pulp, and beef juice. Meat broths and soups contain the *extractives* of the meat, but only a small quantity of proteid. These preparations are all useful in cases of poor digestion, as will be explained presently.

108. *Scraped Beef or Beef Pulp.*—If a piece of lean

beef is scraped with a spoon, a finely divided pulpy mass will be obtained on the spoon and a stringy fibrous mass will remain, which consists of the connective material of the meat. Upon boiling, this fibrous matter is converted largely into gelatin, which gives the "body" to beef soups.

The gastric juice has a particular solvent action on the fibrous matter of meat, and causes the meat in the stomach to swell up and disintegrate into a pulpy jelly, which can easily pass into the intestine where the principal *chemical* changes take place during digestion. As the intestinal juices do not cause meat to swell up and disintegrate, but attack the meat only on the outside surface, digestion is very slow in the intestine unless the gastric juice has first done its preparatory work (11, 151).

In infants the stomach is not fully developed and consequently for them meats are very indigestible. However, if the meat pulp is removed from the connective material, older infants can take care of it without difficulty, as it can easily pass into the intestine where the chemical processes have been established. Scraped beef has a highly nutritive value.

109. *Beef Juice.*—By pressure a certain amount of juice can be obtained from lean beef, especially if the meat has been slightly broiled, which causes it to contract greatly. This juice is not blood, but muscle serum. Its solids consist principally of *fat*, *albumins*, and *globulins*, which coagulate upon heating, certain by-products of proteid metabolism, called *extractives* or *meat bases*, and *salts*.

The proteids of this beef juice or muscle serum are

not the same as those of the muscle plasma that exists in the living muscle. Shortly after an animal is killed its muscles become hard and stiff. This is caused by a coagulation of the muscle plasma; during this process the coagulable proteids are separated from the non-coagulable ones, which can then be expressed with the juice by pressure. This process of separation of proteids is well illustrated in the clotting of blood. It will be seen, then, that beef juice does not represent all the proteids of meat, but only a portion of them.

Another process of preparing beef juice consists of cutting the meat into small pieces and pouring over it cold water, which dissolves out some of the soluble matter, and then pressing. Such juice is poorer in solids than the expressed juice.

Expressed beef juice contains, according to different authorities, quoted by Hutchinson, from two per cent to seven per cent of proteid coagulable by heat.

As a nutrient beef juice is not of great value, because not enough can be given to furnish sufficient nourishment, as it has a tendency to cause looseness of the bowels. It has, however, a great value as a digestive stimulant when given with other foods, as the extractives and salts it contains have a powerful effect in stimulating the appetite and flow of digestive juices. The red color of meat is caused by oxyhæmoglobin, and as some of this passes into the meat juice it has a certain value in furnishing iron in addition to its nutritional and stimulating properties (152).

110. *Meat Extracts.*—If lean beef, cut into small squares, is placed in cold water, a large part of the albu-

mins, globulins, extractives, and salts will dissolve. If the meat is expressed and removed, a diluted beef juice remains. Boiling this juice coagulates the albumins and globulins. When the coagulated matter is removed, a *clear* beef tea or soup remains which contains the extractives and salts of the meat that give it flavor, but little or none of its nutritive elements. When this clear tea or soup is evaporated to a semi-solid consistency, the product is called *extract of beef*. It has all the *flavor* of the beef, while the meat from which it was made is almost tasteless. In making meat extracts, beef is used in preference to other meats because it contains a larger proportion of extractives and salts.

Many believe that the strength and value of meat lie in these extracts and that the meat from which they are made is worthless; but this is not the case. At the close of the Spanish-American war there was an investigation into the process of preparing the so-called canned roast beef that was furnished to the American soldiers and sailors, owing to the charges that it was tasteless stuff made of extracted meat and therefore worthless. This meat was first parboiled to cause it to shrink and thus drive off much of the water it contained; it was then placed in cans and cooked again and the cans were sealed. In the course of this investigation large quantities of meat were put through the process of canning before the court of inquiry, and samples were taken at each stage of the process and analyzed. A single illustration will suffice to show what changes took place in the cooking process and the quantity of nutriment extracted. The meat was placed in water at 50° F. and steam injected. In five

minutes the temperature reached 122° F., and in eleven minutes reached the boiling point. The meat was then boiled for one hour.

598 POUNDS OF FRESH BEEF BOILED ONE HOUR.

Composition of Beef.		Pounds.	*Extracted by Boiling.*		Pounds.
Water		414.6	Water		243.2
Proteids	Coagulated	75.9	Proteids	Coagulated	....
	Globulins	18.3		Globulins	....
	Proteose, Peptones, Gelatin	6.3		Proteose, Peptones, Gelatin	1.3
Meat bases		6.7	Meat bases		3.4
Fat		63.9	Fat		39.2
Ash		6.8*	Ash		4.2†
Undetermined		5.5	Undetermined		....

In this test the shrinkage amounted to 46.49 per cent of the fresh meat. Practically no proteids were extracted.

From this 598 pounds of beef 1,500 pounds of "soup liquor" were obtained, which had the following composition:

Solids	0.92	per cent.
Proteids	.09	"
Meat bases	.23	"
Ash	.28	"
Sodium chloride	.11	"

This soup liquor when evaporated down is used in the manufacture of beef extract. It is easy to see that the extract of beef will have little or no *nutritive* value, but the claims of the manufacturers that one pound of beef extract represents one hundred pounds of beef is not far from correct. Boiled meat may be tasteless, but its nutritive value is not diminished to any extent.

III. *Meat Broths.*—If finely divided meat and cracked

* Sodium chloride, 1.5 pounds.

† Sodium chloride, 1.6 pounds.

bones are boiled for a long time the connective material of the meat and the cartilaginous materials of the bones are converted into gelatin, which is soluble in hot water. Broths so made usually gelatinize on cooling. They contain the salts and extractives of the meat in addition to the gelatin. If the meat which is disintegrated is not strained off, the nutritive value of the broth will be increased just so much. In preparing broths the bones of young or small animals which are not so ossified as those of older animals yield best results. Hence the wide use of chicken, veal, and mutton for this purpose. These broths have a useful place in infant dietetics when milk must be withheld, especially when prepared with cereals (154).

112. *Beef Preparations.*—Within the past few years there has been an increasing number of beef preparations on the market. These may be divided into three classes:

I. Beef extracts prepared from "soup liquor" or other meat as just described. These should be looked upon as flavoring agents.

II. Beef juice prepared by expressing meat as previously described (109). These have about the same value as home-expressed beef juice.

III. Predigested beef, which is composed of albumoses and peptones produced by the articial digestion of beef.

As meats play so small a part in infant feeding, these preparations have not a wide use and will not be described.

Eggs.

113. It is a remarkable coincidence that eggs are as highly specialized in their composition as it has been shown that milks are (6, 31).

Eggs are divided into two great classes.

I. Those from which the young birds emerge developed sufficiently to move about and feed themselves. Example, hen's eggs.

II. Those from which the young birds emerge in a helpless condition and need further development before being able to move about and feed themselves. Example, robin's and sparrow's eggs.

There are wide differences in composition between these two types of eggs.

Hen's eggs have a useful place in feeding infants and young children, as they contain large quantities of cell-building materials (2, 3).

The weight of eggs, according to Hammarsten, varies between 40 and 60 gms.

The *yolk* weighs 12 to 18 gm. and contains, according to Parkes, quoted by Hammarsten:

Water	47.19	per cent.
Proteids	15.63	"
Fat	22.84	"
Lecithin	10.72	"
Cholesterin	1.75	"
Salts insoluble	3.53	"
Salts soluble	6.12	"

The *white* weighs 23 to 34 gms., and contains, according to Hammarsten:

Water	85 to 88	per cent.
Proteid { Ovalbumin, Ovaglobulin, Ovamucoid }	10 to 13	"
Salts	0.7	"
Fats, Soaps, Lecithin, Cholesterin	Trace.	

There are many subdivisions of these ingredients of both the yolk and white of eggs that are not of interest here. It will be noticed that there is an absence of carbohydrates in eggs. The function of carbohydrates in food is to furnish heat. As the mother bird sits on the eggs and keeps them warm during incubation, the developing chick has little need for heat-producing food, and it is not found in eggs. Whole eggs may be looked upon as a tissue-building food, but not as a complete food; for infants or adults need in addition liberal quantities of carbohydrates.

White of egg should not be used as the sole source or main source of proteid for infants, as it cannot build up cells. Experiments in feeding animals with white of egg have shown it not able to support life. In certain forms of indigestion it may be used temporarily with benefit.

Flavor of Eggs.—The flavor of eggs may be the result of two causes: 1. From the hens eating highly flavored or animal food. 2. From changes that take place in eggs that are kept for any length of time, probably due to bacterial infection.

Market Eggs.—Eggs for the New York market, and probably for other large cities, come from a wide area of country and are divided into four grades.

First Grade, or Hennery Eggs. These are from selected breeds of fowls and are from three to five days old when sold.

Only a few high-grade stores have these, and they bring from ten to fifteen cents a dozen above the price of the next grade.

Second Grade, or New Jersey, New York, and Pennsylvania State Eggs, which are about a week old when they arrive in New York. These are what would be generally called first-class eggs and are kept by the best stores.

Third Grade, or Packing Eggs. These are from Illinois, Indiana, Iowa, Michigan, and Ohio, and are at least two weeks old when they arrive in New York. These are the eggs found in the general run of stores.

Fourth Grade, or Kentucky, Missouri, and Tennessee Eggs. The hens that produce these eggs are not carefully fed, being allowed to run at large and eat anything they can find, consequently the eggs are strong in flavor and watery and spoil easily. These are the cheapest eggs that are sold.

Preservation of Eggs.—As the shells of eggs are porous, bacteria find their way into eggs and set up putrefactive changes which soon spoil them. If the egg lies on one side too long the yolk will move to that side and stick to the shell. To preserve eggs from these changes they are often kept cool or immersed in a solution of silicate of soda (water glass) or lime water, which fills up the pores. Eggs kept in silicate of soda solution have been kept three and one-half months without apparent change in flavor or in position of the yolk. When such eggs are boiled, they are apt to burst open as the steam generated inside the shell cannot escape through the closed pores. To overcome this objection egg dealers prick the shell.

Candled Eggs.—A perfectly fresh egg, when held before a candle in a dark room, appears almost translucent.

Cloudiness denotes a change in the egg; when decayed or rotten, it appears very dark or black. This is a very simple way of selecting fresh eggs. An absolutely fresh egg should be obtained in order to get a clear idea of how it appears.

PART III.

CHAPTER XIX.

BREAST FEEDING—DIET AND CARE OF MOTHER—ELIMINATION OF DRUGS IN MILK—CARE OF NIPPLES—CONTRAINDICATIONS—MENSTRUATION—PREGNANCY—WET-NURSING—WEANING AND MIXED FEEDING.

114. When it is possible for the mother to nurse her offspring, comparatively little difficulty will usually be experienced in properly nourishing the infant. In view of this fact all possible foresight should be used in fitting the prospective mother for her duties.

For several months before expected delivery, the nipples should be gently rubbed between the thumb and fingers, depressed or misshapen nipples being thereby drawn out and developed; this also toughens them and prevents possible tenderness or fissure that would interfere with nursing. Tight clothing over the breasts should be avoided. Bathing the nipples with boric acid or borax solution, one-half teaspoonful to a cup of water, promotes cleanliness and thereby tends to avoid possible infection and soreness during the nursing period.

After the mother is sufficiently rested from the labor the baby should be put to each nipple. If this does not satisfy, and the infant becomes fretful or restless, a teaspoonful or so of boiled water may be given. This not only quiets the infant, but helps to wash out the digestive

tract and kidneys. For the first day or two the infant may be put to the breast at three-hour intervals during the day and at four- to six-hour intervals at night; after this every two hours during the day and once or twice at night. The infant should not be allowed to occupy the bed of the mother at night, as this is a common cause of too frequent nursing. *Regularity of feeding is essential, as the composition of milk varies with unequal intervals between nursings.* The shorter the intervals, the richer the milk is in fat, so it is well each day to write down the hours at which nursings are to be given, as 5, 7, 9, 11 A.M., 1, 3, 5, 7, 9 P.M., etc. When the amount of milk is sufficient, the baby will suckle for fifteen or twenty minutes and then drop off contentedly to sleep. If, on the contrary, the baby tugs at the nipple for twenty-five or thirty minutes, and then frets after leaving it, there has not been sufficient milk secreted.

115. In cases in which the milk flow is scanty or does not agree with the infant, particular attention should be paid to the diet and hygiene of the mother. Southworth, who has made a special study of this subject, states that much more than is generally believed can be accomplished in this direction. Nursing is a purely animal function and a great deal can be learned from the study of the secretion of milk by cows. Here it has been found that secreting milk is *hard work*, and that a cow in milk needs as much food as an ox doing heavy work. The best cow is one whose digestive and excretory systems are highly developed and who has *no tendency to lay on fat.* Such a cow is virtually a milk manufactory.

Therefore it is useless to expect any mother to supply

thirty to forty ounces of milk daily, containing about five ounces of solids, the proteid of which is equivalent to about a quarter of a pound of meat, unless she eats and digests a liberal quantity of food.

The diet of the mother should consist of plenty of plain, easily digested food, meat, milk, eggs, and well-cooked cereals (102) predominating. Tea and coffee should be withheld, as they have a tendency to diminish the feeling of hunger and thus cause less food to be eaten and digested, while cocoa and chocolate may be drunk in moderation. Liquid malt extracts may have a beneficial effect by toning up the digestive system, thereby enabling more food to be digested, but not by any particular property of making milk. Southworth recommends to have the mother drink between meals a *bowlful* at a time of a well-cooked and salted gruel made from *yellow* cornmeal. This not only contains nourishment and water that is needed, but undoubtedly has by its coarse particles a beneficial effect in increasing the amount of fæcal matter (27) and thus keeping the bowels regular.

116. It is well known that volatile substances in food readily find their way into milk and that the flavor of a cow's milk is often affected by her food; also that under certain conditions *urea* is found in appreciable quantities in milk. For these reasons highly flavored food should be avoided and strict attention should be paid to the excretory organs, so that products shall not be thrown off with the milk which should pass off in the urine.

Constipation in the mother should be overcome by the use of drugs if copious quantities of the cornmeal gruel do not relieve this condition. In selecting drugs

for this purpose, those whose principal action is on the muscular coat of the bowel, rather than on the glandular apparatus, should be chosen. Cascara is one of the best for this purpose. Anæmia should be overcome by generous diet and the exhibition of iron.

Great care must be exercised in the administration of drugs to nursing women, as they may be excreted in the milk. Thus morphine, mercury, quinine, iodide of potash, and similar preparations, may have a marked effect. This is especially apt to happen when the mother is in a disturbed condition, and consequently the excretory organs and mammary glands are not in a normal state of equilibrium.

117. The great and sudden variations in composition of milk are the result of nervous influences, and as digestion is also greatly affected by anxiety, fright, fear, or other nervous disturbances, particular attention should be paid to keeping the mother in a cheerful state of mind and to seeing that her rest at night is not too much broken. As fresh air is very invigorating, a walk that stops short of fatigue or a drive with pleasant company will have a beneficial effect.

118. In cases in which the mother or nurse is robust and has a plentiful supply of milk that disagrees with the infant, it may prove advantageous to cut down the diet, particularly of proteids (meat, eggs, etc.), as they have a tendency to increase the percentage of fat and proteids in the milk. With the reduction of diet should go an increase of exercise, causing to be used up some of the excess of food eaten, and possibly the exhibition of saline cathartics.

If, with the means indicated, it is impossible to keep the infant steadily gaining in weight, four to six ounces a week, with good digestion and normal stools (**156**), one or two artificial feedings, alternating with breast feedings when possible, should be given daily, as will be explained later (**122**).

Fig. 51.—Nipple Shield.

119. When from fissured nipples or other causes it is impossible for the infant to nurse, the milk may be drawn with a breast pump and fed by bottle or medicine dropper for a few days, until a return to breast feeding is possible. If an abrasion or slight fissure of the nipple causes much pain to the mother, the use of the nipple shield for a day or so may give great comfort and allow healing to take place. The infant often rebels against its use, however, from the difficulty of pulling the milk through. The latter may be partly obviated by filling the shield with warm water at the start, and at the same time massaging the breast, thus getting an easy flow of fluid. Between nursings the nipple must be carefully protected.

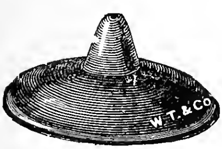


Fig. 52.—Breast Shield.

120. *Contraindications for Nursing.*—Mothers with certain constitutional diseases, especially tuberculosis, should not be allowed to nurse their offspring. When the mother is pale and losing flesh and exhausted by suckling in spite of tonic treatment, the baby must not be continued on the breast. In nervous, excitable women, when every effort has been made to regulate the details of diet and living, and yet the baby does not thrive

and gain after a fair trial, it is best to stop the breast.

Nursing after Menstruation.—The question of nursing after menstruation has been resumed can usually be answered in the affirmative. Any disturbance is usually only temporary and may not recur at the next period. If, however, severe nervous and digestive disturbances regularly occur at each period and interfere with the nutrition of the infant, it may be necessary to remove the breast entirely. Before this is done a trial may be made of giving the bottle during the time of menstruation and then resuming the breast.

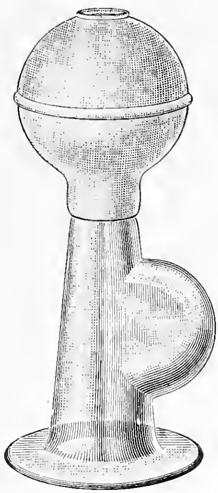


FIG. 53.—Breast Pump.

Intervening Pregnancy.—If pregnancy intervenes it is usually best to give the baby other nourishment. There may be many exceptions, however, to this rule. Thus, if pregnancy occurs during the middle of a hot summer, when the baby is thriving, or in the case of a weak fragile baby with a tendency to digestive trouble, the breast may be continued during the early period of pregnancy; while not ideal, this may prove the best method of feeding available.

121. *Wet-Nursing.*—In many cases in which a mother cannot nurse her infant, a wet-nurse is the best substitute. A wet-nurse is especially indicated when the infant is poorly developed and shows signs of digestive feebleness. The preferable age for the nurse is between twenty and thirty years, and multiparæ usually do better than primi-

paræ, the former having had previous care of the suckling and general charge of infants, which may be of decided advantage.

Too much disparity between the ages of the infants is not desirable, but a woman whose infant is under six months can usually suckle a new-born baby. One advantage of having a wet-nurse with an older infant is that a careful inspection of the nurse's infant will show how well it has thriven upon her milk, and also whether it has derived any constitutional disease, especially syphilis, from the mother. In every case a careful physical examination of the applicant, as well as her infant, should be made by the physician. As changes in the composition of milk are largely the result of nervous influences and changes of diet, a woman of quiet, phlegmatic temperament, in good health, is to be preferred, and when selected her diet should be as nearly as possible that to which she has been accustomed, and she should not be allowed to remain in idleness. A routine life should be established and maintained, as this will insure a uniform milk. The nurse's reward should be in some other form than gratification of her inclinations. This reward should be held out as an inducement for her to comply with directions. After her services are no longer required, she can obtain what she likes with the money she has earned; but if she is furnished a diet she is unaccustomed to, she will in all probability over-eat and bring on either defective digestion or excretion, which will promptly disorder the digestion of the infant.

Several nurses will sometimes have to be tried before a breast that completely agrees with the baby is found.

122. *Weaning and Mixed Feeding.*—Many women who are good nurses show a deficiency in their milk, either in quantity or quality, by the eighth or ninth month. The bottle can here be given with advantage several times during the twenty-four hours, and especially at night, so that the breast can have a prolonged rest. The rate of gain in weight of the baby and the health of the mother will be the gauge as to when mixed feeding should be begun. In any case the baby should be removed entirely from the breast at the end of the first year. Toward the end of lactation the milk becomes unsuitable in composition. This will be shown either by digestive disturbances or loss of weight, or both, on the part of the baby. Weaning should be gradual, and as most babies will require the help of the bottle during the latter part of lactation, it is well to begin as soon as possible in giving one or two bottle feedings each day; the baby will then be educated in its use, the mother will have more time to herself, and in case of her being ill, sudden weaning will not be necessary. If this method is employed, the change from breast feeding to bottle feeding will not cause inconvenience.

Examination and Modification of Breast Milk.

123. In cases in which the mother's milk does not agree with a baby, as shown by constant colic, or stationary or losing weight, the breast should not be withdrawn until every effort has been made to find out and correct the cause of the trouble. Rotch has shown by repeated chemical analyses of mother's milk that much may be accomplished by altering the diet and habits of life to render breast milk, when disagreeing, more fit for any given

case. Each case must be carefully studied in every detail before finally deciding to remove the baby from its mother's breast. There is no doubt that a large number of infants suffer from premature removal; often with a little care and patience lactation could be continued during the normal term.

The careful studies and analyses of Rotch have also shown that nervous, emotional women, or those who nurse their infants at prolonged or irregular intervals, or too frequently, or who are disturbed at night are apt to furnish a poor milk. Regularity in diet, excretion, exercise, rest, and nursing are always to be insisted upon; sometimes it may be necessary to have the mother sleep in a room where she cannot be disturbed by the infant for a few nights, feeding it then by bottle. If, after these precautions have been taken, the milk continues to disagree, an analysis may throw light on the cause of the difficulty. Many analyses of human milk show it generally to contain fat 3 to 5 per cent, proteids 1 to 2 per cent, and sugar 6 to 7 per cent. Undoubtedly there is constant changing and variation in these percentages within certain limits, from day to day, and even from hour to hour, but the infant usually adapts itself to these variations, that doubtless perform a useful function in the nutrition of the child. It is found that variations are mostly in the fats

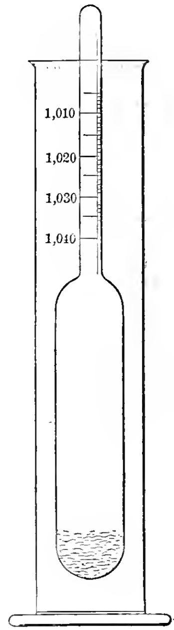


FIG. 54. — From Holt's "Infancy and Childhood." (Copyright, 1897, by D. Appleton & Co.)

and proteids, the sugar remaining quite constant in quantity.

1. If fats and proteids are both low the infant is not getting enough nourishment, and of course cannot gain in weight. A more liberal diet for the mother is indicated. 2. If fats are low (below three per cent), and the proteids normal (one to two per cent), the mother must be fed more meat, eggs, and milk. It is useless to feed her excess of fats, as they will interfere with her digestion. 3. If proteids are high (above two per cent) the mother's meat and milk diet must be cut down. 4. If fat and proteids are both high, the diet must be cut down, particularly the meats, and a liberal amount of out-of-door exercise must be taken. A brisk walk of a mile or two in the open air, twice daily, will sometimes correct an overrich milk. The physician must, however, be specific in his orders, as exercise to the point of fatigue may be required to get results.

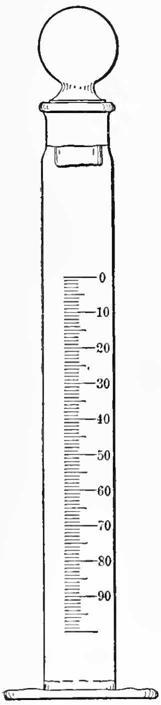


FIG. 55. — From Holt's "Infancy and Childhood." (Copyright, 1897, by D. Appleton & Co.)

When a complete analysis of the milk cannot be had, an approximate analysis may be made by the fat and solids not fat tests, described in the chapter on testing cow's milk. The fat is determined by the Babcock test, and the specific gravity with an ordinary urinometer. About an ounce of milk is required. The entire contents of a breast should be removed and mixed, or very errone-

ous impressions will be obtained, as the fat varies greatly in different portions of the secretion.

Holt has devised an apparatus, consisting of a cream gauge and a small hydrometer, for testing as small a quantity as one-half an ounce of breast milk.

The specific gravity is taken at 70° F., and the milk placed in the cream gauge; after twenty-four hours the percentage of cream may be read. Five per cent of cream corresponds to three per cent of fat. The interpretation of results is shown in the following table by Holt:

WOMAN'S MILK.

	Specific gravity, 70° F.	Cream—24 hours.	Proteids (calculated).
Average	1.031	7%	1.5%.
Normal variations ..	1.028–1.029	8 to 12%	Normal (rich milk).
Normal variations ..	1.032	5 to 6%	Normal (fair milk).
Abnormal variations	Low (below 1.028)	High (above 10%)	Normal or slightly below.
Abnormal variations	Low (below 1.028)	Low (below 5%)..	Very low (very poor milk).
Abnormal variations	High (above 1.032)	High	Very high (very rich milk).
Abnormal variations	High (above 1.032)	Low	Normal (or nearly so).

CHAPTER XX.

METHODS OF SELECTING FOOD FOR ADULTS NOT APPLICABLE TO INFANTS—NUTRITION AND DEVELOPMENT OF THE DIGESTIVE TRACT MUST BE CONSIDERED TOGETHER.

124. When it becomes impossible to supply an infant with its mother's milk or that of a suitable wet-nurse, recourse must be had to some substitute food. This may be done in two ways: (1) By telling the mother or nurse to try everything that is suggested by kind friends until something is found that "agrees"; or (2) scientifically to adjust the food so that the infant's future well-being will be conserved.

A. V. Meigs, of Philadelphia, made the first attempt at scientific infant feeding by trying to adjust or modify cow's milk so that it would resemble mother's milk in composition. Later, Rotch, of Boston, emphasized the importance of systematic "percentage feeding," which consists of trying to make from cow's milk a mixture that contains accurate percentages of fat, proteids, carbohydrates, mineral matter, and water, and varying these percentages to suit the requirements of each particular infant. Other workers have contributed their quota to the advancement of scientific infant feeding with the result that many formerly accepted beliefs and doctrines have

been modified or completely abandoned. At present it is not accepted that there is *one*, and *only one*, way of scientifically feeding an infant. While there may be differences of opinion as to methods of feeding, there are certain principles involved which are beyond dispute and about which there can be only one opinion.

125. It has been shown (1) that true growth consists principally of an increase of protein in the body by a process of cell division (2), and the addition of mineral matter to the bones. (2) That protein cannot be elaborated by the infant, but must be taken in as such with the food. (3) That there are many forms of protein, some of which are not tissue builders and can only put off the time when death will result from starvation (24). (4) That the first demand of the animal organism is for heat-producing food, and that during starvation normal heat is kept up by destruction of the tissues (22). (5) That the function of fat and carbohydrates in the body is to produce heat (19).

It follows that one of the first problems of scientific feeding is to determine the quantities and quality of the protein (tissue builder) and fat and carbohydrates (heat producers) needed for a given individual. This problem has been pretty well worked out for adults, and is generally performed as follows: 1. From the quantity of nitrogen in the urine during a period of fasting is determined the amount of protein used up daily. There is no advantage in feeding more than this quantity to an adult as it is only excreted (20). 2. From the quantity of oxygen consumed is calculated the quantity of heat produced.

The standard for measuring heat values in dietetics is called a *large calorie* and is the amount of heat required to raise the temperature of one litre of water (2.2 lbs.) 1° C. or 1.8° F.

The heat produced by the combustion of 1 gm. of protein is about 4.1 calories; of 1 gm. of carbohydrates, about 4.1 calories; of 1 gm. of fat, about 9.3 calories, or about two and one-quarter times that of either protein or carbohydrates.

It has been found that a man doing ordinary muscular work requires daily about 125 gm. (= 4 oz.) of protein and enough other food to produce about 3,000 calories. In selecting the food for such a man it is only necessary, theoretically, to see that his food contains 125 gm. of digestible protein and enough heat-producing food to produce 3,000 calories. Adding the results obtained by multiplying by 4.1 the weight in grams of the protein and carbohydrates, and by 9.3 that of the fat contained in any food, will give the total number of calories it will produce.

Tables have been prepared showing the composition of most articles of food in general use, expressed in percentages of digestible protein, fat, and carbohydrates, and it is a simple matter to calculate from these analyses the quantities required properly to nourish a person.

For a healthy adult there are many articles of diet that are interchangeable, weight for weight almost, as their composition and digestibility are practically the same; for this reason it makes little difference which article is used.

The following analyses by Atwater illustrate this statement:

	Protein, per cent.	Fat, per cent.
Corned rump of beef	16.7	5.1
Turkey	16.1	5.9
Shoulder of veal	16.6	7.9
Halibut	15.1	4.4

In preparing food for infants this method of selecting food cannot be employed, as will be explained further on.

The proportion between the digestible protein and heat-producing elements in food is called the *nutritive ratio* and is thus determined. As fat has about two and one-quarter times as much fuel value as carbohydrates, the weight of the fat is multiplied by two and one-quarter and added to the weight of the carbohydrates. The proportion between the weight of the protein and the weight of the heat producers, calculated as carbohydrates, is the nutritive ratio.

Example. A food contains:

Fat, 2 per cent; protein, 10 per cent; carbohydrates, 50 per cent.
Fat, 2 per cent $\times$ 2¼ = 4.5 per cent, equivalent in carbohydrates.
Carbohydrates, = 50.0 per cent

54.5 per cent $\div$ 10 per cent protein = 5.45.
Nutritive ratio, 1–5.45.

This is about the ratio required by adults.

There is a wider nutritive ratio in human milk, which we should strive to imitate, than in an adult's food, as can be seen by a glance at analyses of this milk that are within the range of variation:

Human Milk.

Fat, per cent.	Proteid, per cent.	Sugar, per cent.	
3	1	6	Nutritive ratio, 1–12.75.
4	2	7	Nutritive ratio, 1–8.

In human milk not only is there a variation in composition, but also in the nutritive ratio. The much greater proportion of heat-producing elements in the infant's natural food than in the adult's food is in part accounted for by the fact that there is a much greater radiation of heat from an infant's body; metabolism is also much more active.

At first thought nothing seems more rational in artificial infant feeding than taking the milk of some of the lower animals and adjusting the percentages of fat, proteids, and sugar, and the nutritive ratio, so that they shall approximate those of human milk. Adjusting diets for adults on this percentage and nutritive ratio plan is very successful, but unfortunately not so successful in feeding infants, as it is often impossible for a young infant to digest the same percentage of the proteids of cow's milk as is found in woman's milk.

In feeding adults, in whose fully developed digestive systems a great variety of foods can be digested equally well, it is only necessary to see that enough of fat, proteids, and carbohydrates are furnished to maintain the body.

In feeding infants or young animals, whose digestive systems are not fully developed, it is not only necessary to supply the proper quantities of nutritional elements, which include more ingredients than fat, proteids, carbohydrates, and mineral matter, but they must be in such form as *normally to develop* the digestive tract.

It has been shown in chapters IV. and VIII. that the milk of each species of animal is highly specialized for these two purposes. For these reasons it is not to be expected

that a perfect substitute for human milk will ever be produced. The most that can be done is to provide a food whose composition is as nearly like human milk as our imperfect knowledge of milk permits us to make, and to have it in such form that it will allow a normal use and development of the digestive tract.

126. *Development of the Digestive Tract.*—In chapters iv., viii., it was shown that all animals are similar in the early stages of their development, but that as they become more developed they assume the characteristics of the parents. The digestive tracts are all alike and simple in these early stages and also become specialized as development progresses. When a young suckling animal is born it has never used its digestive tract, the cells of the body having been nourished by the blood stream of the mother. The process of absorption of food from the digestive tract takes place principally in the intestines, and the first secretion of the mammary glands is not milk but colostrum, which is quite different from milk, in that it requires little digestion and does not form curds in the stomach. Colostrum contains the same general food elements as milk—fats, proteids, carbohydrates, mineral matter, and water—but in different *forms.* It can be absorbed with little effort, as its proteids are soluble and the sugar is dextrose and not the sugar of milk. The function of colostrum seems to be to furnish nourishment and to start up the digestive process of the intestines. In the course of a few days after birth the character of the mammary secretion begins to change. The soluble proteid and dextrose of colostrum are largely replaced by casein and milk sugar, and normal milk secretion is established. A peculiar and

distinguishing constituent of colostrum is the presence of *colostrum corpuscles* (Fig. 56). Colostrum will coagulate when boiled. When the mammary secretion shows no colostrum corpuscles and does not coagulate when heated it is said to be milk. It may be ten to twenty days after birth before colostrum is entirely displaced by milk (Figs. 56, 57, and 58).

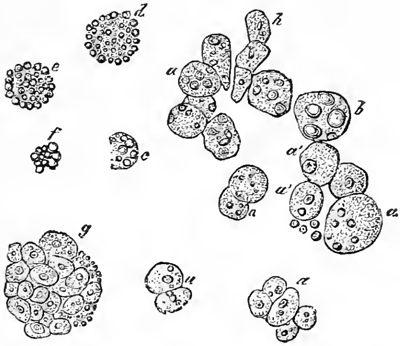


FIG. 56.—Colostrum Bodies. (× 300.) *a′*, Cells with nucleus; *a*, cells undergoing fatty degeneration; *b*, cells containing large drops of fat; *c*, cells with a partially destroyed cell membrane; *d*, *e*, and *f*, cells which have entirely lost the cell membrane; *g*, cell masses from the milk canals. (Aikman.)

This secretion of colostrum and gradual displacement by milk is common to all suckling animals, but when the milk flow is established wide differences in the character of the milk secreted by different animals are found.

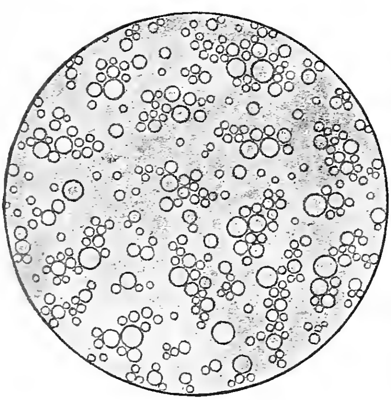


FIG. 57.—Normal Human Milk. (Jewett.)

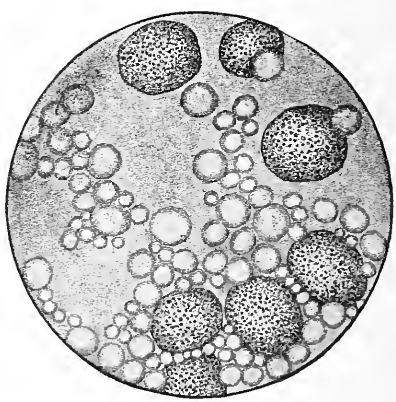


FIG. 58.—Colostrum Corpuscles. (Jewett.)

During the colostrum period there is little secretion of digestive juice in the young animal's stomach. As the milk begins to displace the colostrum the stomach of the young animal begins to secrete rennet, a ferment which acts upon the casein of milk, changing it into paracasein, which is a solid or gelatinous mass or curd, depending on what kind of milk is acted upon. Junket, the familiar dessert, is cow's milk in which the casein has been changed into paracasein by rennet. The milk of animals whose digestion takes place principally in the stomach forms solid curds that leave it with difficulty (cow's, goat's and sheep's milk). The milk of animals whose digestion is principally intestinal forms soft gelatinous curds which easily pass into the intestines (mare's and ass' milk). The human digestive tract stands between these two types, and consequently neither cow's nor ass' milk fits it.

The rennet, acting upon the milk, changes it into a semi-solid mass much like chyme which is ready to be passed into the intestines. The pepsin of the stomach will not attack the curds formed by the rennet. When hydrochloric acid is secreted by the stomach it combines with the rennet curds—paracasein—and forms mono- and bichloride of paracasein, compounds which are readily acted upon by pepsin. As more acid is secreted it combines with more of the rennet curds and gives more work for the pepsin secreted. In this way the work of the stomach increases as fast as its secretion of digestive juice increases; mother's milk thus automatically adapts itself to the normal young animal's digestive apparatus. If mother's milk did not alter to meet the increased quantity

of the digestive juices, the infant's stomach would find less work as it grew stronger, with consequent atrophy.

For this reason the feeding intervals become longer as the infant grows stronger. While at first little digestion takes place in the stomach, as the digestive secretions of the stomach become greater they alter the milk so that it requires gastric digestion, and consequently the stomach does not empty as rapidly.

During the suckling period the infant should be looked upon as being a fœtus and not as a perfectly formed human being. That this view is the correct one is evidenced by the lower forms of animal life in which there is no placental connection between the parent and young, but a mammary attachment, the fœtus growing fast to the teat and being nourished by mammary secretion ejected by the mother into the gullet, long before it is developed sufficiently to suck, when it ceases to be adherent to the teat and sucks at will, much as any other young animal (Figs. 10–12 and 59).

Fig. 59.—Head of Mammary Fœtus of Kangaroo Hemi-sected to show Adaptation of Teat to Mouth. See also Figs. 10 to 12. Life size. (Photograph of specimen in the Zoological Collection of Columbia University.)

During the suckling period of the kangaroo its digestive tract changes greatly and there can be no doubt that the mother's secretion adapts itself to the altered digestive tract (6, 32 B).

To recapitulate: colostrum develops the absorptive process of the intestines; the casein of the milk, by being changed by the rennet of the stomach into a solid or semi-solid, develops the motor function of the stomach, and by combining with the acid of the stomach as fast as it is secreted, develops the chemical function of the stomach.

After the stomach is developed, teeth appear and the mechanical portion of the digestive tract (5) is still further developed, weaning takes place, and the infant becomes independent of its mother's body. In the infant, the development of the digestive tract covers a period of about two years, so it is manifestly out of the question to use methods of selecting food for infants that are adapted for adults. It should be remembered that nature has no *one* food for the infant, but that the mother adapts the food to the state of development of the baby, at one time even changing the character of the proteid and sugar secreted by the breast. The great underlying principles of infant feeding consist in furnishing sufficient food and adapting it to the state of the infant's digestive tract. What nature does automatically must be imitated by the most successful feeders.

It must be clearly borne in mind in infant feeding that nutrition and development of the digestive tract must be considered together. Little progress will be made if only a calculation of the composition of food is made. This is a small part of scientific infant feeding, although by many writers on the subject an undue amount of attention has been given it, which has made infant feeding appear to be a complicated subject. As a matter of fact, when the principles of artificial infant feeding are grasped,

the process becomes as simple as diluting condensed milk, and the most scientific food that can be conceived can be prepared in any home with very little effort.

The principles of preparing infant food will be considered in the next chapter.

CHAPTER XXI.

GENERAL CONSIDERATIONS IN PREPARING INFANT'S FOOD.

Breast Milk as Pattern—Effect of High and Low Protein—Value of Percentage Feeding—Cream and Milk Mixtures—Bottled Milk—Top Milk—Diluents.

127. In preparing an artificial food for infants nature should be followed as closely as possible. The food should compare with human milk in its nutritive value, which is determined by chemical analysis, in physiological properties, or its behavior in the digestive tract, and in the manner and condition in which it is supplied to the infant.

In composition, human milk is variable, but it is generally believed that it contains as a rule between 3 per cent and 5 per cent of fat, 1 per cent and 2 per cent of proteid, 6 per cent and 7 per cent of sugar, and 0.2 per cent and 0.3 per cent of mineral matter. No attempt is made to take account of its other ingredients. In its physiological properties it is specially adapted for developing the infant's digestive tract, owing to the character of its protein.

There has been a great deal of discussion as to what forms of protein exist in human milk. Chemists have not agreed on this point and with improved methods of analysis different results are continually being obtained. Some authors call the protein of milk casein or caseinogen and lactalbumin, and many analyses have been published

showing the percentages of these ingredients. Other chemists, using later and improved methods, have found large quantities of other forms of protein, especially in woman's milk; also that the casein of human milk has not the same properties as that in other milks. Varying results have also been obtained in examination of the sugar of milk (28).

Though the composition of the milk of any animal is variable and no definite conclusion can be reached as to the character of the protein of different milks, one characteristic stands out clearly, and that is, the protein of each milk is especially adapted for the digestive tract it was intended to supply. Though young animals readily tolerate a variation in quantities of the protein of their natural milk, they are promptly disturbed when the protein of the milk of another type is supplied to them. The fats and sugars cause little trouble. As all young animals thrive on their mothers' milk irrespective of its type, and as all animal life requires the same ultimate food elements, the differences between the milks of different animals must be more physiological than chemical.

None of the lower animals furnishes a milk that approximates human milk in physiological properties even after the percentages of fat, proteids, and sugar have been adjusted to equal those of human milk. In the breast the ingredients of the milk are not secreted uniformly, the greater quantity of fat being in the latter part of the flow; furthermore, the milk has not undergone bacterial changes.

In feeding an infant artificially it is impossible to secure a food whose ingredients have the same physiological properties as those of human milk, to imitate the

process of secretion, or generally to obtain milk free from bacterial change. Therefore it should always be kept in mind that *anything aside from breast milk that is put into an infant's stomach is a foreign substance that may cause digestive disturbance.* This is one of the fundamental principles of infant feeding.

128. Though nutrition and development of the digestive tract should be considered together, nutrition comes first, and in cases of poor digestion it is justifiable to use anything that will sustain the infant until normal digestion is re-established; then the food should be changed so as to cause proper development. Many feel that after something that "agrees" and causes gain in weight is found, the problem of successful feeding has been solved; but the future of the infant may be completely wrecked by such a method of feeding. For instance, an infant is receiving as much fat and sugar as is found in human milk and only one-fourth to one-half as much protein. The infant is fat and gaining in weight, and to all appearances healthy, yet it can be predicted with reasonable certainty that this infant will become rachitic or succumb to the first serious illness. As resisting force comes from the protein of the food, it is apparent that a bottle-fed infant who receives but one-fourth to one-half as much protein as a breast-fed infant will not be so rugged or will have as good a chance of surviving. What a difference a too small amount of protein in the food of a growing animal will have on the tissues and health of the adult has been shown by W. A. Henry, of the Wisconsin Experiment Station.

It had been noticed that pigs that were fed on a diet rather low in protein readily succumbed to disease. They

were very fat, but when slaughtered yielded a relatively small amount of lean meat or muscular tissue. To determine the effect of rich and poor protein diet on the bones and tissues Henry and others made some extended experiments. A number of healthy young pigs were selected; part were reared on a diet low in protein and the others on a diet high in protein. At maturity both lots were slaughtered and their bodies analyzed.

The following figures from Henry will give an idea of the immense advantage to a growing animal of a diet high in protein. After an animal has matured there is no such advantage.

Blood per 100 pounds weight:	
High protein diet	51.2 ounces.
Low protein diet	36.8 "
Liver per 100 pounds weight:	
High protein diet	48.4 ounces.
Low protein diet	31.9 "
Muscular tissue:	
One third more on high protein diet.	
Strength of bone:	
High protein diet.	Thigh bone broke at 503 pounds pressure.
Low protein diet.	Thigh bone broke at 380 pounds pressure.

FIG. 60.—Fed Low Proteids. Very Fat. (Carlyle.)

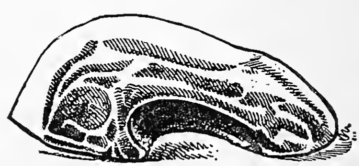


FIG. 61.—Fed High Proteids. Very Muscular. (Carlyle and Hopkins.)

FIGS. 60 and 61 show Character of Flesh resulting from Feeding with Low and High Proteids.

It will be seen that a food that causes gain in weight is not necessarily a good food for an infant. The scales are not a safe guide by themselves in judging of an infant's development.

It is right here that thinking in percentages, as advocated by Rotch, is of the greatest value. It enables any one readily to compare the nutritional value of a substitute food with that of human milk. There is nothing complicated about it. All that is necessary is to have a general idea of the composition and digestibility of various foods that are used in infant feeding. For instance, human milk contains nearly 2 per cent of protein, and cow's milk diluted three times about 1 per cent; it is evident, therefore, that an infant that is getting this diluted milk will receive only about half as much tissue-building food as the infant that gets breast milk. If in the human milk there was about 4 per cent of fat and 7 per cent of sugar, the breast-fed infant would have an immense advantage over the infant getting the cow's milk diluted three times, which would contain only about 1.3 per cent of fat and 1.3 per cent of sugar. In all probability the breast-fed infant would be gaining in weight and strength while the bottle-fed baby would be weak, puny, and losing in weight. Under the old haphazard methods of feeding it would have been thought that this baby could not thrive on fresh cow's milk and it would have been fed on some proprietary food or condensed milk, with possibly a prompt gain in weight as a result, for reasons that will be given later. Under modern methods of thinking it would be known at a glance that the great trouble with the diluted cow's milk lay in its not supplying enough heat and energy-producing food. It could not be expected that getting only one-half the quantity of protein and one-quarter of the quantity of heat-producing food found in breast milk the bottle-fed infant could thrive. In the proprietary foods and condensed milk, as usually prepared

for the infant, there is a larger quantity of heat-producing food (sugar) than is used up, which enables the infant to lay on fat and not use the protein for fuel; the result is gain in weight. If sugar had been added to the diluted cow's milk, gain in weight would also have followed.

129. The problem of infant feeding does not consist simply of supplying protein and heat-producing food, of which sugar is a good example. Fat of milk contains *lecithin*, which is an important constituent of the nervous system, so it is necessary to see that an infant's food contains an amount of milk fat equal to that found in human milk, particularly as cow's milk contains less lecithin than human milk. As stated in the previous chapter and in chapter IV., the curding of milk is for the purpose of developing the digestive tract, so it is essential that the basis of an infant's food should be the milk of some other animal, although there is no milk that is exactly like human milk in curding properties. Though other forms of protein will nourish an infant, they do not cause its digestive tract to develop naturally.

Cow's milk, which must be the basis of an artificial infant-food, was intended to nourish a calf that grows much more rapidly than an infant, and therefore contains much more protein than human milk. This protein was also intended for digestion in the stomach and forms solid curds which cannot readily leave the stomach. In an infant digestion takes place principally in the intestine, and human milk is especially adapted for easily leaving the infant's stomach. In the calf and cow, digestion, which takes place principally in the stomach, is prolonged, so when cow's milk is put into the infant's stomach it is not to be wondered at that it slowly leaves the stomach, or

that curds are vomited or appear in the stools. This curd question has been before infant feeders ever since cow's milk began to be used for infant feeding, and probably always will be.

To reduce the quantity of protein in the infant's food and also to modify the character of the curd, milk is diluted with various substances which will be described later. This diluting reduces the fat and sugar and they must be added if the food is at all to approximate human milk in composition.

In many methods of preparing infant's food it has been recommended that certain quantities of cream of assumed richness be mixed with milk to increase the fat, and the mixture then diluted; for each infant a special formula had to be calculated which was burdensome, and besides cream is so inconstant in composition that no accuracy could be insured no matter how exactly the calculations were made. If centrifugal cream (43) was used, the emulsion of the fat was destroyed and there was a separation of the proteids (45); if gravity cream was used, the cream might be nearly twice as rich or only one-half as rich as it was thought to be. Where one infant thrived on a formula, another that apparently needed the same food was completely upset by it when prepared from different milks and creams. In one instance to which the author's attention was called, it was calculated that the infant was getting four per cent fat; an assay showed nine per cent, which explained an attack of indigestion. Many of the unsatisfactory results that have followed the use of cream and milk mixtures might have been avoided and much simpler methods of preparing food used had there

been a better general understanding of the nature and composition of milk and cream.

130. It is widely believed that cow's milk contains fat 4 per cent, proteids 4 per cent, sugar 4 per cent, and gravity cream fat 16 per cent, and about the same quantity of proteid and sugar as whole milk. Now it is known that milk may contain anywhere from 3 per cent to 5 per cent of fat, from 3 per cent to 4 per cent of proteids, and from 4 per cent to 7 per cent of sugar; and gravity cream as low as 10 per cent and as high as 28 per cent of fat, so it is not to be wondered at that widely differing results were obtained with mixtures made after the same formula but with different milks and creams (38).

One of the reasons that condensed milk is so popular as an infant's food is the ease with which it can be prepared for the infant's bottle; simply mix so much condensed milk and so much diluent. Any quantity can be made up; enough for one feeding or for all day. Now it is almost as easy to prepare from fresh cow's milk a food containing the quantities of fat, proteids, and sugar that are within the range of those found in human milk by the method about to be described.

131. In human milk there is from two to three times as much fat as proteid. In cow's milk the quantities of fat and proteid are about equal. If cow's milk is allowed to stand for any length of time, the fat, being lighter than the other ingredients of the milk serum, will rise to the surface as cream. Whereas before the cream rose the quantity of fat and proteid in the milk was uniform throughout the entire quantity of milk, it is now apparent that in the upper creamy portion there will be many more

times as much fat as proteid. If in this upper milk there can be found a quantity which will uniformly contain between two and three times as much fat as proteid, preparing the infant's food will be a simple matter, requiring only the removal of this quantity from the top, diluting it, and adding sugar. By the use of bottled milk such a method can be carried out anywhere with the greatest ease and with the best results. Before describing the method in detail an explanation of the advantages and composition of bottled milk will be given.

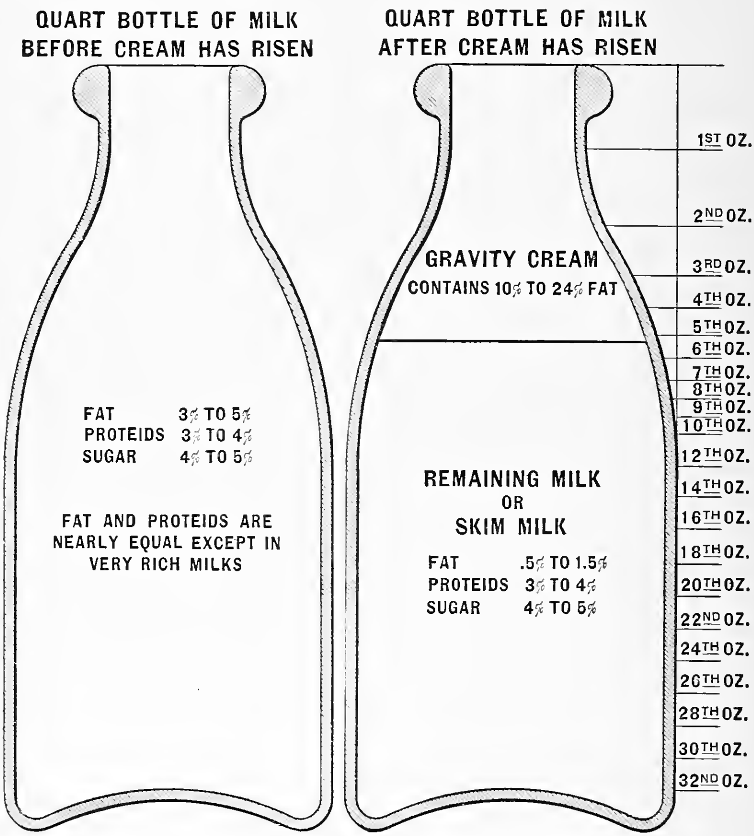
132. It has been shown that the bacteria which get into milk do not grow to any extent if the temperature is below 50° F. (**60, 65**), and that cream rises rapidly if the milk is quickly cooled to below this point immediately after milking (**41**). If as soon as possible after milking the mixed milk of several cows is bottled and kept cool, the low temperature will retard the growth of bacteria and cause the cream to rise; thus when this milk is delivered to families it will be fairly free from bacterial change and in condition to use at once in preparing the infant's food, and will not vary much in composition from day to day.

It is a remarkable fact that in bottled milk there is generally about the same *quantity* of cream no matter how rich the original milk was; but the richness of the cream varies greatly. One day the author had purchased nine quarts of bottled milk on which the cream had risen. When set in a row there was hardly any perceptible difference in the depth of the layer of cream in any of the bottles.

The milk and cream were then tested for fat. The poorest milk contained 3.1 per cent fat and the richest

4.6 per cent. The poorest cream contained 11.2 per cent fat and the richest 23 per cent. At other times creams poorer and richer in fat were obtained.

The range of composition of whole milk before and after the cream has risen can be seen by a glance at the following illustration:

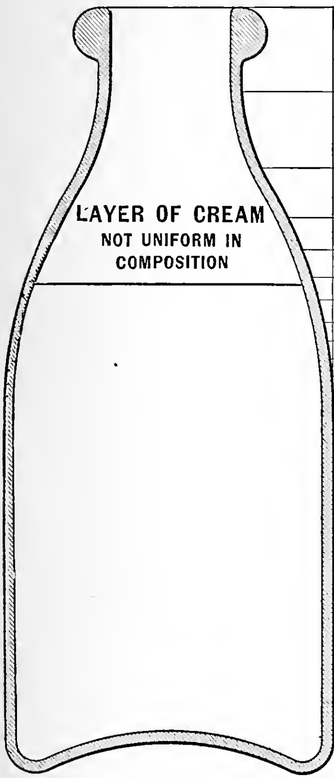


FIGS. 62. and 63.—Milk Before and After Cream has Risen.

The richness of the cream in fat depends a great deal on the size of the fat globules. In milks poor in fat the globules are very small (36) and rise slowly, hence cream

from such milk is thin and bulky. In milks rich in fat the globules are larger and have greater buoyancy, hence they rise quickly and with some force. Cream from such milk is very dense near the top. For these reasons the layer of

ONE QUART MILK
4.1% FAT
WITH CREAM RISEN



LAYERS OF CREAM NOT UNIFORM IN COMPOSITION.

FAT IN EACH OUNCE.			FAT IN DIFFERENT PORTIONS REMOVED FROM THE TOP AND MIXED.			
1ST OZ.	CONTAINS	25% FAT				
2ND OZ.	"	23% "	TOP	2 OZS.	MIXED	24% FAT
3RD OZ.	"	19% "	"	3 OZS.	"	22.5% "
4TH OZ.	"	18.5% "	"	4 OZS.	"	21.4% "
5TH OZ.	"	10.5% "	"	5 OZS.	"	19.2% "
6TH OZ.	"	4.8% "	"	6 OZS.	"	16.8% "
7TH OZ.	"	3.4% "	"	7 OZS.	"	15.0% "
8TH OZ.	"	2.2% "	"	8 OZS.	"	13.3% "
9TH OZ.	"	1.8% "	"	9 OZS.	"	11.5% "
10TH OZ.	"	1.2% "	"	10 OZS.	"	10.5% "
12TH OZ.	"	1.2% "	"	12 OZS.	"	9.0% "
14TH OZ.	"	1.2% "	"	14 OZS.	"	7.8% "
16TH OZ.	"	1.2% "	"	16 OZS.	"	7.0% "
18TH OZ.	"	1.2% "	"	18 OZS.	"	6.3% "
20TH OZ.	"	1.2% "	"	20 OZS.	"	5.8% "
22ND OZ.	"	1.2% "	"	22 OZS.	"	5.4% "
24TH OZ.	"	1.2% "	"	24 OZS.	"	5.0% "
26TH OZ	"	1.2% "	"	26 OZS.	"	4.7% "
28TH OZ.	"	1.2% "	"	28 OZS.	"	4.5% "
30TH OZ.	"	1.2% "	"	30 OZS.	"	4.3% "
32ND OZ.	"	1.2% "	ALL MIXED			4.1% "

FIG. 64.—Showing Distribution of Fat in Bottled Milk After Cream has Risen.

cream in the bottles is not at all uniform in composition, it being sometimes two or three times as rich in fat near the surface as near the junction with the remaining milk.

The illustration above shows how the fat varies in

different portions of the creamy layer. This milk had been passed through a centrifugal machine to remove dirt, and hence there was not so complete a separation of fat (42) as would have taken place in natural milk, as shown by the high percentage of fat in the skimmed milk, which is not usual.

The table at the right of the bottle shows the composition of different quantities of the cream when mixed; also of mixtures of all the cream and varying quantities of the remaining milk. It will be noticed that every ounce of remaining milk that is added to the cream reduces the quantity of fat in the mixture and that a great many mixtures, each containing a different quantity of fat, can be had from one bottle of milk. Glancing along this table it will be seen that the top *nine* ounces contain 11.5 per cent of fat, or about three times that of the whole milk, and the top 16 ounces 7 per cent, or nearly two times that of whole milk. These *proportions* hold good with any milk rich or poor, but the percentages of fat will vary, as shown by the following assays of poor, medium, and rich milk:

	Fat—per cent.		
Whole milk	**3.1**	**4.2**	**4.8**
Top 6 ounces	13.4	19.0	23.0
" 7 "	11.6	16.4	19.8
" 8 "	10.2	14.1	17.3
" 9 "	9.2	12.6	15.5
" 10 "	8.4	11.4	13.9
" 11 "	7.7	10.4	12.7
" 12 "	7.1	9.6	11.7
" 13 "	6.6	9.0	10.8
" 14 "	6.2	8.3	10.0
" 15 "	5.8	7.8	9.4
" 16 "	5.5	7.4	9.0
Skim milk	.7	.6	.4

Milk poor in fat yields top milk poor in fat. Milk rich in fat yields top milk rich in fat. This does not complicate matters; as rich milk is diluted more than poor milk, so rich top milk is to be diluted more than poor top milk.

The next step is to see what separation takes place in the proteids and sugar, or solids not fat, of the milk, as the cream rises. For this purpose two quarts of milk were taken; one was milk obtained from a milkman and then bottled and tested after having stood four hours for the cream to rise; the other was a quart bottled by the milkman and delivered in the usual way, the cream having risen.

The top nine ounces were removed from each bottle and tested for fat and solids not fat (sugar and proteids) by the methods described in the section on milk testing (Chap. XIV.). It was found that there was only a slight falling off in the quantity of proteids and sugar in the top milks, as will be seen in the illustration (Fig. 54).

It will be noticed that the cream did not separate completely in the milk that was obtained from the milkman and stood in the bottle but four hours. This was because it was not bottled immediately after milking. Cream rises quite completely in four hours if the milk is bottled shortly after milking, but not otherwise.

From these illustrations it will be seen that it is hopeless to expect any degree of accuracy in making up food mixtures of milk and cream unless each is assayed, or to have the food uniform from day to day; but if definite quantities are removed from the top of a quart bottle of milk after the cream has .risen, nearly the same composition will be obtained each day, as a milkman's milk usu-

ally is quite uniform from day to day, and the strength of the food can be varied with the greatest ease by increasing or decreasing the dilution of the top milk. Any desired proportion between fat and proteids can be had by taking

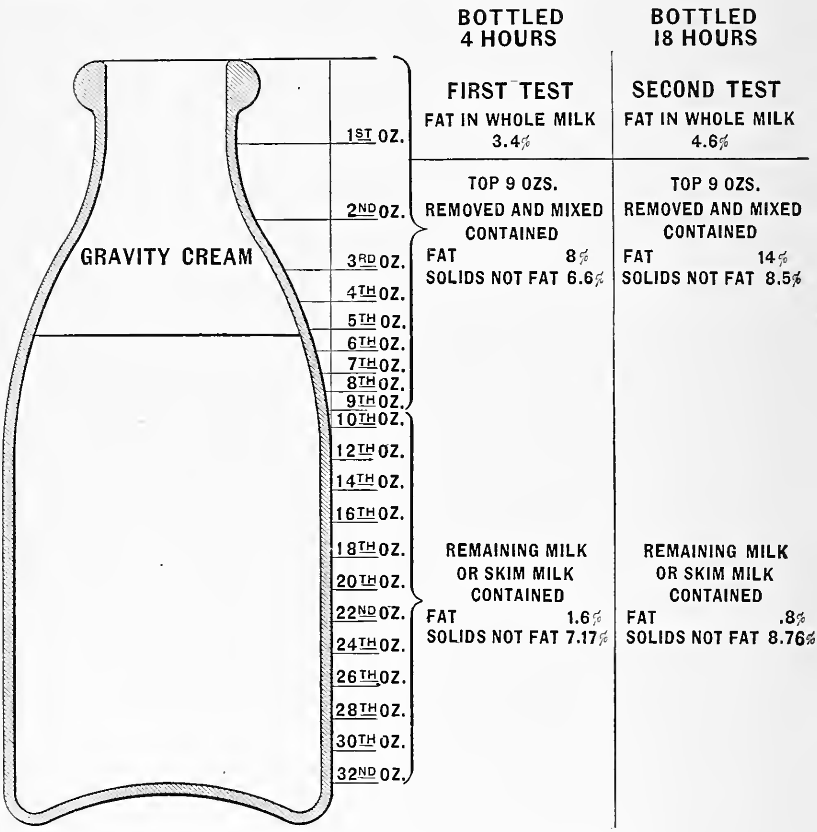


FIG. 65.—Showing Solids not Fat in Top Milk and Remaining Milk.

a greater or less quantity from the bottle. By varying the richness of the top milk in cream, and the dilution, the composition of the food can be varied to suit the infant's digestion. It should be remembered that percentages should be calculated *after* something that agrees with the

infant has been found; it is then time to see if the food contains enough proper nourishment. This method allows the greatest variation in composition of food without any calculation, and when a food that suits the infant's digestion is found its composition can be known within a slight fraction, especially the protein, which is of such importance.

These top milks should be looked upon as concentrated milks that require dilution to suit the infant's digestion. Of course sugar must be added. About five or six per cent is the usual quantity required. This would be about one ounce of sugar to twenty ounces of food, or one-twentieth of any mixture (128).

An easy way of bringing to mind the percentages obtained by various layers of milk may be acquired by tabulating the ingredients of 9 and 16 ounce top milk. It is

		Fat. Per cent.	Proteids. Per cent.	Sugar. Per cent.
Very rich milk. Butter fat, five per cent. High grade, blooded Guernseys and Jerseys	Top 9 ounces.	15	4	4
	Top 16 ounces.	9	4	4
Rich milk. Butter fat, four per cent. Ordinary Guernseys and Jerseys.....................	Top 9 ounces.	12	4	4
	Top 16 ounces.	8	4	4
Thin milk. Butter fat, three per cent. Holstein and ordinary milk cows	Top 9 ounces.	9	3	4
	Top 16 ounces.	6	3	4

based upon the fact that the proteids in whole milk equal the fats up to 4 per cent. In actual practice milk varying from 3 to 5 per cent butter fat will be met. If the milk contains 3 per cent fat, it will have about 3 per cent proteids; 4 per cent fat, 4 per cent proteids, but 5 per cent fat in milk is accompanied by only about 4 per cent pro-

teids. While the butter fat in milk can be determined only by assay (75), certain grades of cows give a fairly uniform milk in this respect.

It will be noticed that the top 9 ounces give a ratio of fats to proteids of 3 to 1, and the top 16 ounces a ratio of 2 to 1, whether the milk is rich or thin. Hence practically the same percentages will be obtained by this method no matter what kind of milk is used. Rich milk will be diluted more and poor milk less to preserve the proper proportions. It is thus merely a matter of dilution, when we know the general strength of the whole milk. To find the percentages actually given to the baby, divide any of the above figures by the dilution. Thus, one part of top milk to three parts of diluent will give a dilution of 4.

Example:

		9 oz. Top Milk.				16 oz. Top Milk.		
		Fat.	Proteids.	Sugar.		Fat.	Proteids.	Sugar.
Very rich milk.	4)	15	4	4	4)	9	4	4
		3¾	1	1		2¼	1	1
Rich milk.	4)	12	4	4	4)	8	4	4
		3	1	1		2	1	1

To get about the same percentages from thin milk use one part of top milk to two parts of dilutent, giving a dilution of 3.

		Fat.	Proteids.	Sugar.		Fat.	Proteids.	Sugar.
Thin milk.	3)	9	4	4	3)	6	3	4
		3	1	1⅓		2	1	1⅓

We can thus, by varying the *dilution* in a sliding scale, get a wide variation in percentages. In cases of indigestion it is simply a question of dilution, according to whether the fats or proteids are disagreeing. If we wish to run down the fats, dilute a thin top milk, or even whole milk. If we wish to keep the fats high, dilute a rich top

milk. A glance at the table will suggest many possible variations. The proper strength of the food must depend upon the digestive power as shown by the stools. In diluting cow's milk, the top pint of a quart of milk when creaming has taken place, even if simply poured off, contains a ratio of fats to proteids of about 2 to 1. In diluting whole cow's milk, it is only necessary to remember that the fats and proteids are about equal in thin and moderately rich milk, the former containing fats and proteids 3 per cent, the latter fats and proteids 4 per cent. Both grades contain sugar about 4 per cent.

133. *Diluents.*—There has been a great deal of discussion as to what diluent should be used. Jacobi has advocated for years the use of cereal waters on account of their rendering the curds of cow's milk softer; objection has been raised to this method on the ground that nature was not being followed, as no human breast secreted cereals. This argument is offset by the fact that no human breast has been known to secrete cow's milk, which was intended for so different a digestive tract (Chaps. IV., VIII.).

No diluent has been proposed that does not have some effect on the curding of cow's milk. There is no denial of the efficacy of the cereal waters, but their opponents claim that they get as good results with plain water in most cases. It will be noticed that lime water is always to be added when plain water is used. This is stated to be for the purpose of rendering the milk alkaline. It was formerly thought that cow's milk was acid and that breast milk was alkaline in reaction, and that in modifying cow's milk to imitate breast milk some alkali should be added; lime water, bicarbonate of sodium, and carbo-

nate of potassium have been recommended for this purpose. If cow's milk was really acid, as the term acid is generally understood, the addition of sodium bicarbonate should cause an effervescence of carbonic acid gas, which is not the case, for the addition of weak acids to fresh milk containing sodium bicarbonate causes a brisk effervescence of gas which shows that the *milk* had not decomposed the soda. By careful examinations of breast milk and cow's milk it has been found that both will take considerable quantities of lime water to render them alkaline to phenolphthalein. Breast milk requires 8 to 24 per cent, and the very best cow's milk 50 to 95 per cent. It is thought that it is the mucin of the milk that neutralizes the lime water, as the milk swells up and becomes viscid under the action of the lime. Swelling up in alkalies is peculiar to mucin. This effect is not noticeable when the sodium bicarbonate is added. The conception of acids and alkalies and the methods of detecting them have undergone a great change within the past few years, with more knowledge of chemistry, and it is now known that litmus paper is a very unreliable, unscientific reagent to use in making comparisons of breast milk and cow's milk (82). The so-called radical difference between human milk and cow's milk of alkalinity and acidity has disappeared, and it is known that alkalies added to cow's milk prevent the stomach secretions from acting on the milk so as to form curds. In other words, the addition of alkalies to cow's milk for infant feeding has the effect of enabling the food to leave the stomach quickly and to pass into the intestines in a soft or fluid condition. The addition of alkalies to milk should be applied to the individual

case as indicated and not necessarily be made a routine measure.

Owing to the character of the curd of cow's milk, young infants cannot always take the quantity of protein that the breast-fed infant receives, which largely accounts for the well-known greater mortality of bottle-fed infants. It may be months before the bottle baby receives half as much cell-building material as the breast-fed. For this reason and others to be mentioned in another place (158) the author believes that the best general diluent for cow's milk is a cereal gruel in which the starch has been dextrinized or rendered soluble by the action of diastase. This gruel, which may be made from any cereal, renders the curds of cow's milk more flocculent, and also increases the quantity of tissue-building protein the infant receives and digests, oftentimes by fifty to one hundred per cent, which is of great value. In the milks of all animals there is more or less soluble nutriment that can be absorbed without digestive effort, and particularly so in woman's milk. Diluting cow's milk, which contains less soluble nutriment than woman's milk, reduces the quickly absorbable part of the food to almost nothing. This is partially replaced by the digested starch of dextrinized gruels, which is easily absorbed and assimilated. The youngest infant can usually assimilate these gruels, in fact in many cases there is no other form of nourishment so well borne. The advantages of this form of diluent are: (1) It acts mechanically on curds; (2) it furnishes tissue-building proteid in appreciable amount; (3) it forms the best temporary substitute for milk; (4) it is always at hand when wanted; and (5) it can be easily and cheaply prepared (17).

At the Pan-American Medical Congress of 1893 the author proposed a method of preparing these gruels, which, however, proved to be too complicated for general use. Since then an easier process has been worked out (**137**).

A simple decoction of diastase for dextrinizing gruels may be made as follows:

A tablespoonful of malted barley grains crushed is put in a cup and enough cold water added to cover it, usually two tablespoonfuls, as the malt quickly absorbs some of the water. This is prepared in the evening and placed in the refrigerator over night. In the morning the water, looking like thin tea, is removed by a spoon or strained off, and is ready for use. About a tablespoonful of this solution can be thus secured and is very active in diastase. It is sufficient to dextrinize a pint of gruel in ten or fifteen minutes. Such a decoction must be prepared each day as it soon spoils, owing to the unstable nature of the enzyme (**11**). For this reason it may be more convenient to use some commercial preparation of diastase. Of the many in the market the author uses and prefers a glycerite of diastase known as Cereo, which is specially made for dextrinizing gruels. This retains its activity indefinitely and under varying temperatures owing to the menstruum employed.

Dextrinized or Digested Gruels.

Much misapprehension exists as to dextrinized cereal gruels. Cereals, like all foods, contain fats, proteids, carbohydrates, mineral matter, and water. The carbohydrates are principally starch and a delicate cellulose or cell wall. Diastase dissolves starch and transforms it into

a number of products depending largely on the conditions under which it acts. When cereals are boiled with water the starch grains swell up and rupture (Fig. 47), forming gelatinized starch or starch paste which is soluble in water to a very slight extent. This gelatinized starch forms an intensely blue color with tincture of iodine or with iodine test solution.

When diastase is added to cereal gruels at a temperature of about 150° F. the gelatinized starch passes into *soluble* starch, and the gruel thins rapidly. In a short time the soluble starch is transformed into *dextrins* and partly into maltose. This transformation may be followed by testing with iodine a small drop of the gruel diluted with a test tube full of *cold* water, every two or three minutes after the diastase has been added. The blue color gradually fades away as the starch is transformed. If it is desired to produce a very small quantity of maltose, the gruel may be boiled as soon as it is liquefied. The heat will destroy the diastase and prevent much action on the starch except liquefaction. In practical infant feeding no attention need be given to the particular products of the starch transformation, as they are the same as those that are produced in the livers of all animals which produce glycogen. The youngest infant has such products in its circulation and readily assimilates digested gruels.

When the starch of the gruel has been dissolved, there remain the coagulated proteids of the cereal and the delicate cell walls, cellulose, which are in a loose, flocculent condition, and which render the curds of cow's milk more porous. Dextrinized gruels containing as high as 3 per cent proteids, and 12 per cent soluble carbohydrates, may

be made, and form an excellent diluent for milk for older children and adults in fever diets. These gruels not only render milk more digestible, but also have a favorable action on digestive secretion.

134. There are a certain number of cases that every physician meets in which cow's milk, even in the highest dilution, will not be tolerated temporarily. To some this is a source of mortification, especially when the mother tries some proprietary food with a prompt gain in weight as a result, after the doctor's efforts with cow's milk have failed. The trouble here is, the doctor has been trying to make the baby conform to his theory of what it ought to take instead of trying to find what it could take, and then adjusting the food as rapidly as possible so that it would contain enough protein to build cells, and enough fat and carbohydrates to produce heat and energy.

In this class of cases condensed milk is often the best thing to start with, after being modified as described in the following chapters. The great objection to condensed milk is not that it is condensed, but that the food elements are out of proportion.

135. In many cases in which the appetite is poor or digestion very weak, food is required that stimulates the appetite and flow of digestive juices, or that can be absorbed with little digestive effort. It is here that beef juice, scraped beef, broths, peptonized milk, whey, eggs, and gruels find their usefulness.

CHAPTER XXII.

PREPARATION OF FOOD.

Top Milk Mixtures — Pasteurization — Percentage Composition—Whey and Cream Mixtures—Whey —Peptonized Milk—Scraped Beef—Beef Juice— Beef Tea—Meat Broths—Egg Mixtures—Milk Laboratories.

In the previous chapters the character of the food required to develop the tissues and organs has been described and the method of securing the raw materials. In this chapter will be given the methods of preparing them for use of the infant under different conditions.

Top Milk Mixtures.

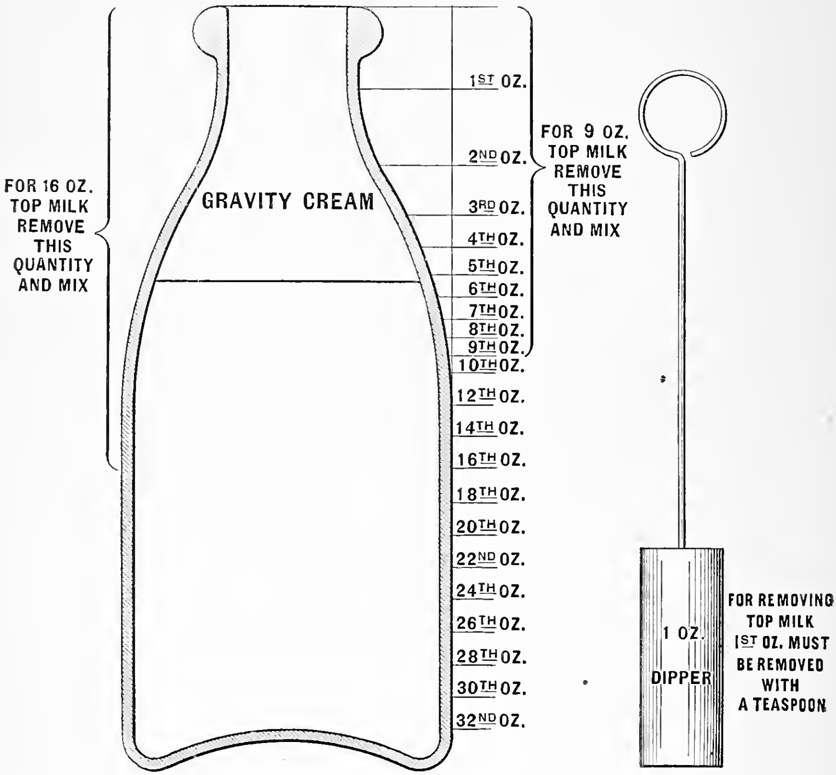
136. *Top Milk.*—Use the mixed milk of a herd of cows. Have it bottled and cooled as soon as possible after milking. "Certified Milk" (68) should be obtained when possible. When such milk is delivered the layer of cream will be distinct in the neck of the bottle.

For young infants, remove from the top of a quart bottle all the cream and enough milk to make nine ounces, and mix in a pitcher or bowl for dilution. This is called nine-ounce top milk. (Fat to proteids, 3 : 1.)

For older infants, remove from the top of a quart bottle all the cream and enough milk to make sixteen ounces (one pint) and mix in a pitcher or bowl for dilution. This is called sixteen ounces top milk. (Fat to proteids, 2 : 1.)

The top milk can easily be removed by using the au-

thor's dipper* shown in the illustration. The first dipperful must be removed with a teaspoon, as inserting the dipper into the full bottle will cause it to overflow. If a



Figs. 66 and 67.—Quart Bottle of Milk Ready for Use, with Dipper.

siphon is used to remove the milk from under the cream, the sediment—there is always some—goes into the infant's food, and the manipulation is rather difficult.

Since the introduction of this dipper in 1899 many have suggested that the bottom would push the cream

* These dippers may be made by any instrument maker and are inexpensive to produce.

down into the milk. This seems plausible, but a great many assays of the milk after the cream has been removed show that this is not the case.

137. *Diluents: Sugar Water, Plain Cereal Gruel, or Dextrinized Gruel.* Beat up one to two heaping tablespoonfuls of barley, wheat, or rice flour with enough cold water to make a thin paste; or use two to four heaping tablespoonfuls of rolled oats. Pour on a quart of boiling water and *boil* for at least fifteen minutes, preferably in a covered double boiler as the gruel will not then burn. If the mixture is to be dextrinized after it is cooked, place the cooker in cold water, and when the gruel is cool enough to be tasted add one teaspoonful of diastase solution, or Cereo, and stir (133). This will thin the gruel. Strain, add salt to taste, and cool.

Wheat, barley, and rice are well absorbed and should be used when the bowels move naturally. Oatmeal contains considerable coarse material that stimulates the bowels, and should be used when the bowels are constipated.

138. *Sugar* is not added to sweeten the food, but to supply heat-producing food. The dipper holds one ounce of granulated sugar; two level tablespoonfuls also equal one ounce. Three level tablespoonfuls of milk sugar equal one ounce. Either may be used.

Preparation of Food.

139. Before attempting to prepare the food dip a strip of blue litmus test paper into the top milk. If the color is only slightly changed the milk is fresh. If the color is changed to dull red, the milk is beginning to sour. It will be bright red if the milk is quite acid.

For Young Infants.—One part of the nine-ounce top milk should be mixed with 3 to 8 parts of the diluent, and 1 part of sugar added to 20 to 30 parts of food; granulated or milk sugar may be used.

For Older Infants.—One part of the sixteen-ounce top milk should be mixed with 1 to 2 parts of the diluent, and 1 part of sugar added to 20 to 30 parts of food; granulated or milk sugar may be used.

In every instance begin on a weak mixture and gradually decrease the dilution.

Any quantity may be mixed, from about two ounces up to enough for twenty-four hours.

In making up a small quantity a teaspoon, dessert-spoon, tablespoon, or the dipper may be used as a measure.

EXAMPLE: Mixture about 2 ounces one-fifth top milk.
2 teaspoonfuls of 9 ounce top milk (after being removed from bottle and mixed).
8 teaspoonfuls of diluent.
—
10 teaspoonfuls; add one-twentieth sugar, or one-half teaspoonful.

When the dipper is used, greater accuracy in *quantity* will be obtained and the result will be a definite number of ounces which is not the case when a teaspoon or table-spoon is used, as these vary in size. This does not affect the strength of the mixture, however.

EXAMPLE: Mixture 12 ounces one-third top milk.
4 dipperfuls (4 ounces) 16-ounce top milk (after being removed from bottle and mixed).
8 dipperfuls (8 ounces) diluent.
—
12 dipperfuls (12 ounces); add one-twentieth of sugar, or one-half ounce.

A quart graduate may be used in making up enough for all day; all that is necessary is to know how many ounces of the top milk, diluent, and sugar are to be mixed. It

is easy to remember that one part of sugar is to be added to twenty to thirty parts of food, and that two level tablespoonfuls of granulated or three level tablespoonfuls of milk sugar equal one ounce.

140. After the food has been prepared it should be placed in separate nursing bottles and these plugged with

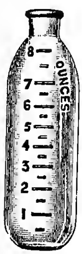


Fig. 68.—Nursing Bottle.

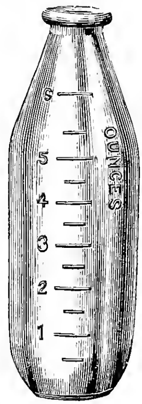


Fig. 69.—Nursing Bottle, Preferable.

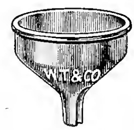


Fig. 70.—Funnel for Filling Bottles.

clean cotton and kept on ice or in a refrigerator away from meat or vegetables, where the temperature is below 50° F. The temperature of many refrigerators is above 60° F. and the milk should then be put in the ice receptacle.

A self-registering maximum and minimum thermometer is kept in the refrigerator of the babies' wards of the New York Post Graduate Hospital, and during an entire year the temperature of the refrigerator did not fall below 40° F. During the summer months the range of temperature was from 50° F. to 65° F. This refrigerator is undoubtedly much better than those in ordinary use, so the necessity of having the food kept in the ice receptacle, or in cracked ice, will be apparent. When the temperature of the food is likely to rise above 60° F., it is best to pasteurize the food—heat to 155° to 165° F.

The Freeman pasteurizer or Arnold sterilizer may be used for this purpose; or a pasteurizer may be made from a six-quart tin pail. A false bottom is made by punching holes in a tin pie plate, which is to be inverted in the pail; this prevents the bottom of the bottles getting too hot. It is best to have a thermometer pass into the water through a cork fitted in a hole in the cover.

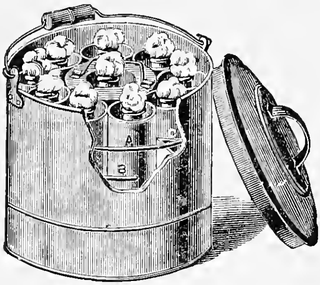


FIG. 71.—Freeman Pasteurizer.

The bottles are placed in water up to the level of the milk and the water is heated up to 165° F. The pail is then removed from the heat and covered with a cloth and allowed to stand for half an hour. Where a thermometer cannot be had, the water should be brought nearly to the boiling point before being removed from the heat. The bottles are then cooled by first being placed in luke-warm water and then in cold water. Pasteurized milk should be kept below 60° F., or the spores in the milk will develop into active bacteria (48). A simple and practical method of keeping nursing bottles cool, suggested by De Forest, is to place cracked ice around them in the pasteurizer; this saves possible infection from food in a refrigerator.

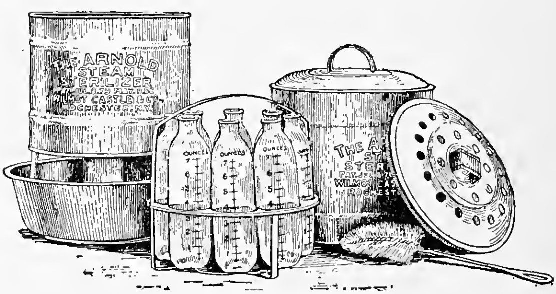


FIG. 72.—Arnold Sterilizer.

A quart bottle of milk may be pasteurized without dis-

turbing the cream by setting it in a kettle or pail and heating as just described.

Sterilizing (heating to 212° F.) is not employed so much as formerly, as the taste of the milk is greatly altered and certain chemical changes are also produced. There are no corresponding advantages that offset these objections (**61**).

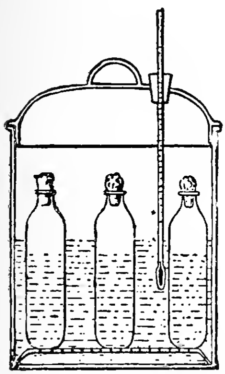


FIG. 73.—Home-made Pasteurizer. (Russell.)

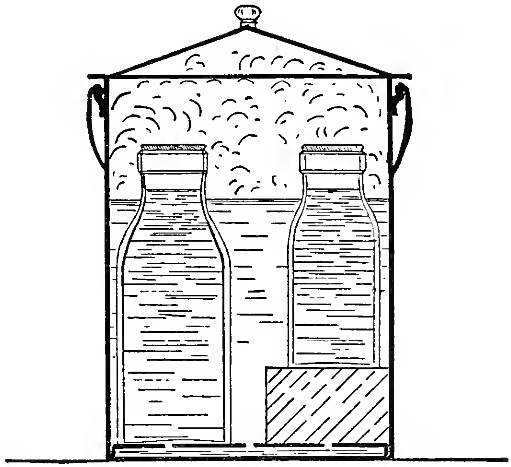


FIG 74.—Pasteurizer for Bottled Milk. (Russell.)

When conditions are such that pasteurization as described cannot be carried out, the milk may be brought to a boil, preferably in a double boiler, and then covered and allowed to stand for twenty minutes and then cooled.

141. *Lime water* added to the food often proves beneficial, especially when there is vomiting or when the milk is slightly acid to litmus paper. It may be obtained at a drug store or readily prepared at home as follows: Get a lump of lime at a grocery store. Pour on a quart of water in an open vessel and allow it to slake. When this process is completed and the lime has settled, pour off the

clear liquor at the top, as this contains the potash and soda and other soluble impurities in the lime. Stir up the lime with another quart of water and pour off as before; this will leave the lime quite pure. The lime may then be placed in a large bottle or quart fruit jar and this filled with water. When the lime water is clear it may be poured off into any convenient bottle for use, and more water poured on the lime. This may be repeated as long as any lime remains undissolved, but it is well to use a new lump of lime every two or three months.

142. *Syrup of lime* is about thirty times as strong as lime water and can be had at any drug store. Where it is not convenient to obtain or make the lime water, one ounce of syrup of lime may be added to a quart of boiled water or one teaspoonful to four ounces. It may also be added directly to the feedings, about one or two drops to a bottle.

Composition of Mixtures.

143. It is impossible to tell the exact composition of mixtures, as that will depend on the richness of the original milk, but the range of composition will always fall within the following limits, without the solids of the diluent and the sugar.

9 oz. Top Milk.	Lowest Extreme. 9 oz. Top Milk from Milk Three Per Cent. Fat.			Highest Extreme. 9 oz. Top Milk from Milk Five Per Cent. Fat.		
	Fat. Per cent.	Proteids. Per cent.	Sugar. Per cent.	Fat. Per cent.	Proteids. Per cent.	Sugar Per cent.
Diluted 8 times*......	1.10	0.38	0.50	2.00	0.50	0.50
" 7 "	1.30	.43	.57	2.30	.57	.57
" 6 "	1.50	.50	.67	2.67	.67	.67
" 5 "	1.80	.60	.80	3.20	.80	.80
" 4 "	2.25	.75	1.00	4.00	1.00	1.00
" 3 "	3.00	1.00	1.33	5.60	1.33	1.33

* Diluted 8 times means, 1 part top milk, 7 parts diluent, etc.

16 oz. Top Milk.	Lowest Extreme. 16 oz. Top Milk from Milk Three Per Cent. Fat.			Highest Extreme. 16 oz. Top Milk from Milk Five Per Cent. Fat.		
	Fat. Per cent.	Proteids. Per cent.	Sugar. Per cent.	Fat. Per cent.	Proteids Per cent.	Sugar. Per cent.
Diluted 8 times*......	0.7	0.38	0.50	1.12	0.50	0.50
" 7 "	.8	.43	.57	1.30	.57	.57
" 6 "	.9	.50	.67	1.50	.67	.67
" 5 "	1.1	.60	.80	1.80	.80	.80
" 4 "	1.4	.75	1.00	2.25	1.00	1.00
" 3 "	1.8	1.00	1.33	3.00	1.33	1.33
" 2 "	2.7	1.50	2.00	4.50	2.00	2.00

A dextrinized gruel will contain from 0.3 to 0.5 per cent proteids, 2 to 4 per cent soluble carbohydrates, depending on whether one or two heaping tablespoonfuls of cereal flour is used to the quart, which adds to the nutritive value of the mixture.

In calculating percentages of sugar the following figures will be found exact and simple:

One	part	sugar	to	twenty	parts	mixture	adds	five	per cent.
"	"	"	"	twenty-five	"	"	"	four	"
"	"	"	"	thirty	"	"	"	three	"
"	"	"	"	forty	"	"	"	two and a half	"
"	"	"	"	fifty	"	"	"	two	"

144. The principle of preparing food with the dipper admits of many applications. Cragin has devised an outfit called the "Sloane Maternity Milk Set,"† consisting of a measuring glass graduated for twenty ounces of food, and the author's dipper. The top milk is removed from the milk bottle and mixed.

Directions for Use.

Get a quart bottle of good milk and let it stand on ice or in a cool place for half an hour so that the cream will show at the top of the bottle.

* Diluted 8 times means, 1 part top milk, 7 parts dilutent, etc.

† This milk set is made by James T. Dougherty, 411 West 59th St., New York.

From the upper part of the bottle are obtained two kinds of *top milk:*

Top Milk No. I., obtained by taking ten dipperfuls from the top of the bottle, the first dipper being filled with a spoon to prevent spilling, the remaining nine dipperfuls being taken by dipping carefully from the bottle. These ten dipperfuls are to be mixed in a clean pitcher, and from the milk thus mixed the baby's food may be prepared until it is from four to six months old.

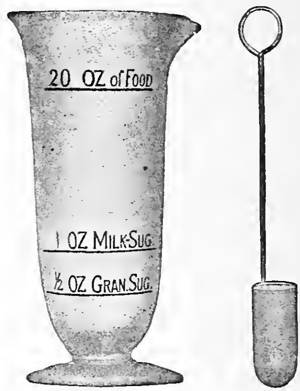


Fig. 75.—Sloane Maternity Milk Set.

Top Milk No. II., obtained by taking sixteen dipperfuls from the top of the bottle, the first dipper being filled as before with a spoon, the remaining fifteen dipperfuls being taken by dipping carefully from the bottle.

These sixteen dipperfuls are to be mixed in a clean pitcher and from the milk thus mixed the baby's food may be prepared from the age of about four months until it is a year old.

In using this milk set, whatever strength of food is desired, the sugar and the lime water are always the same: one ounce of milk sugar (or one-half ounce of granulated sugar) and one ounce (one dipperful) of lime water.

The quantity of food made by filling the glass once is always the same—twenty ounces. The strength of the food varies with the number of dipperfuls of top milk used.

Preparation of the Food.

First. Into the measuring glass pour milk sugar up to the line marked one ounce milk sugar, or granulated sugar up to the line marked one-half ounce granulated sugar.

Second. Add one dipperful of lime water and mix by shaking the glass.

Third. Add the required number of dipperfuls of top milk according to the age of the baby as explained below.

Fourth. Fill the measuring glass up to the line marked twenty ounces of food, with water, either plain, or barley water, or oatmeal water.

During the first month it is usually better to use plain water, after that barley water, or if the baby is very constipated oatmeal water.

Strength of Food for Different Months.

First day—Give no milk; put in milk sugar to mark, then fill with boiled water.

Second day—Add one dipperful of top milk No. I.

Third day—Add two dipperfuls of top milk No. I.

Fourth day—Add three dipperfuls of top milk No. I.

Fifth to tenth day—Add four dipperfuls of top milk No. I.

Tenth to thirtieth day—Add five dipperfuls of top milk No. I.

One month to two months—Add six dipperfuls of top milk No. I.

Two months to four months—Add seven dipperfuls of top milk No. I.

Four months to nine months—Add ten dipperfuls of top milk No. II.

When the baby needs more than twenty ounces in the twenty-four hours, fill the measuring glass twice instead of once, before putting the food into the baby's bottle.

After nine months the food is prepared by shaking the quart bottle of milk when first obtained and using the plain mixed milk.

After preparing the food put it (especially in hot weather) on the stove and heat it till it simmers. It is then ready to be placed in the baby's bottles which have been thoroughly washed in hot soapsuds and rinsed.

The above directions are given for an average healthy baby. A frail baby or one whose weight is below the average will need to have the strength of food increased more slowly. A very strong, healthy baby may have the strength of the food increased more rapidly. If the stronger food does not seem to agree with the baby, decrease the number of dipperfuls of milk used.

By increasing or decreasing the number of dipperfuls of milk, the food can usually be adjusted to the child's digestion.

Whey and Cream Mixtures.

145. Bartley's Formula:* From one quart of milk after the cream has risen siphon off the under three-fourths (this leaves the top eight ounces in the bottle). Place the under milk that was removed in a double boiler and "add a teaspoon and a half of good essence of pepsin and warm slowly to blood heat and keep at that temperature until thoroughly curdled. Now heat with constant stirring until a thermometer dipped into the milk shows a tem-

* Brooklyn Medical Journal, May, 1900.

perature of 155° F. and remove from the fire; strain, while hot, through a clean wire strainer and dissolve in the whey a heaping tablespoon of sugar of milk and the white of one egg. When cold pour the sweetened whey back into the milk bottle and mix thoroughly with the cream and top milk."

"To reduce caseinogen we draw off more of the bottom milk. To increase it, draw off less. To decrease fat, dip off a part of the cream. . . . To increase the fat, add a little less than the full amount of whey after removing the curd. To increase the soluble albumins, add more white of egg. The sugar may be varied at will by adding more or less as desired." The object of heating the whey to 155° F. is to destroy the rennet in the essence of pepsin that causes the milk to coagulate. Otherwise the top milk would curd when mixed with the whey.

Westcott * has published some elaborate formulæ for calculating the percentages of the fat, caseinogen, and lactalbumin in whey and cream mixtures, and a method of preparing mixtures. The principles involved are practically the same as Bartley's, except that no white of egg is used.

The original object of the whey and cream mixtures was to make a substitute food that should contain the same protein ingredients as human milk, assuming these to be definite proportions of caseinogen and lactalbumin, and thereby overcome the trouble caused by the curding of cow's milk. The experiments of White and Ladd † led them to report "that whey has a distinct value as a

* International Clinics, October, 1900. American Journal of the Medical Sciences, October, 1901.

† Philadelphia Medical Journal, February 2d, 1901.

diluent in making the casein coagulum finer, but is inferior in this respect to barley water."

Since the analyses on which these schemes of preparing food are based were published, much advanced work with the proteids of the milk of different animals has been done, and it is now known that the older belief as to the composition of milks and the proportions between casein and lactalbumin has been wrong, especially in the case of woman's milk (32).

In many cases whey and cream mixtures are well borne, but the proteids of whey do not seem to have as much nutritive value as the proteids of the original milk from which it was made, it having been found in experiments in feeding two hundred and fifty-eight animals during an extended period that one part of skim milk produced as much gain in weight as two parts of whey; and slaughter tests showed the flesh of the whey-fed animals to be inferior to that of those fed skim milk.* The great difference will be seen by the following approximate comparison:

	Proteids.	Sugar and salts	Total solids.
100 c.c. skim milk	3.29 gm.	5.71 gm.	9.00 gm.
200 c.c. whey	1.74 "	11.58 "	13.32 "

Foods For Temporary Use.

146. *Whey.*—Get some junket tablets at any grocery or drug store. Dissolve one of these in an ounce (two tablespoonfuls) of cold water and add this to a quart of fresh milk. Warm gently until a little above blood heat. When the curd has become quite solid beat up well with

* Henry: "Feeds and Feeding," p. 586.

a fork and keep warm until the curds have shrunk considerably. Then strain off the whey and set on ice. Keeping the curd warm for ten or fifteen minutes greatly increases the yield of whey. Wine may be added as a flavoring agent if desired.

147. *Peptonized Milk. Warm Process.*—(1) Empty into a clean quart bottle the contents of one of Fairchild's peptonizing tubes; (2) add four ounces (eight tablespoonfuls) of cold water; shake, and (3) add one pint of cool fresh milk and again shake; (4) place the bottle in water not too hot to be uncomfortable to the hand, for ten minutes. Then either place on ice, or boil, to prevent further digestive action. This milk is likely to taste bitter.

Cold Process.—Prepare the bottle as before, but set on ice without warming. This milk is only partially peptonized so will not have a bitter taste.

148. *Egg Water.*—Beat up the white of one egg in eight ounces of cold water and add a pinch of salt. This may be flavored with a few drops of aromatic spirits of ammonia or of whiskey.

Booker* has given the following formula: Egg water is made by beating the white of egg in a shallow dish, allowing it to stand for two or three hours, then pouring off the clear fluid, leaving the foam behind. The fluid is soluble in five parts of water. It should be diluted with a larger quantity of water when the digestion is feeble, and made palatable by the addition of sugar, salt, and a few drops of lemon juice.

149. *White of Egg and Dextrinized Gruel.*—Add to eight ounces of dextrinized wheat flour gruel (137) the

* "Eleventh Annual Report of the Thomas Wilson Sanatorium for Children."

white of one fresh egg, and if well borne add one to two even teaspoonfuls of granulated sugar. Composition about 2 per cent proteids and 4 to 7 per cent carbohydrates.

150. *Yolk of Egg and Dextrinized Gruel.*—Add to eight ounces of dextrinized wheat flour gruel (137) the yolk of one fresh egg and if well borne one to two teaspoonfuls of granulated sugar. Composition about 1.5 per cent fat, 1.5 per cent proteids, 4 to 7 per cent carbohydrates. These egg mixtures may be heated up to 150° F. without coagulating, hence they may be given warm if desired.

151. *Scraped Beef or Beef Pulp.*—Get a piece of steak perfectly free from taint or sliminess, which is caused by bacterial decomposition (54); with a tablespoon scrape the meat until nothing but fibre remains. The pulp may be salted and broiled slightly, or fed raw (108).

152. *Beef Juice.*—1. Slightly broil a thick piece of steak that is free from the slightest trace of taint or sliminess; cut in small pieces and press in a clean meat press or lemon squeezer. The yield of juice is not large. 2. Cut the meat into small squares and just cover with cold, slightly salted water, and set on ice for several hours. Then press by squeezing in a piece of cheesecloth (109).

153. *Beef Tea.*—Cut a pound of lean meat into small squares and let stand in a pint of cold water for an hour. Heat to not above 160° F. and express the meat through cheesecloth. This tea will contain considerable nourishment. If heated higher, the proteids will coagulate. If the coagulum is fed, none of the nutritive value will be lost; if removed, the tea will simply have a flavor. The nutritive value may be greatly increased by leaving some of the meat pulp in the tea.

154. *Meat Broths.*—Take one pound of lean mutton, veal, or chicken with some cracked bone and cut into small squares; add one pint of cold water, heat gently and allow to simmer for several hours; remove all the fat. On cooling these broths will gelatinize (111). These broths, especially when thickened by the addition of flour, are highly nutritive.

155. *Milk Laboratories.*—The teachings of Rotch have resulted in the establishment of the Walker-Gordon laboratories for the preparation of infant's food.* The infant's food is put up as a prescription. The physician fills out the following prescription blank:

THE WALKER-GORDON LABORATORY.

	Per cent.		Remarks.
℞ Fat			Number of feedings ?. . . . .
Milk sugar			Amount at each feeding ?. . . . .
Albuminoids			Infant's age ? . . . .
Mineral matter			Infant's weight ? . . . .
Total solids			
Water			
	100	00	
FOR WHOM ORDERED.			
Date,			Signature,
. . . .			. . . .

If the physician does not care to mention the especial percentages, he can ask for percentages which will correspond to the analysis of average human milk, and he can then vary any or all of these percentages later, according to the need of the special infant prescribed for.

* These are located in Baltimore, Buffalo, Cincinnati, Cleveland, Grand Rapids, Montreal, New York, Ottawa, Philadelphia, Pittsburg, Providence, St. Louis, Toronto, Washington, D. C., and London, England.

The attendants at the laboratory make up the food by mixing the quantities of centrifugal cream (43), skimmed milk, sugar, and water necessary to produce the desired percentages. It sometimes requires considerable experience to know what percentages of these ingredients a given infant can digest, and often a great deal of shifting of percentages is necessary before the proportions that agree are found. The laboratories stand ready to put up these and any other food mixtures that may be desired.

Without a knowledge of dietetics a food laboratory is of little value to a physician, who must have a knowledge of the percentages required by various conditions to use this valuable agent intelligently. It would be as creditable to send his patients to a pharmacy to find out what drugs they needed, as to send them to a food laboratory to find what particular food combination they should use.

CHAPTER XXIII.

SELECTION AND ADMINISTRATION OF FOOD.

Infant's Stools—Stomach Capacity—Care of Nursery Utensils.

156. From the time of birth until the second set of teeth is supplied there is a gradual development of the digestive process and tract in the following order (126):

1st. The process of absorption.

2d. The production of a stool and emptying of the bowel.

3. The secretion of the digestive juices.

4th. The development of the stomach (by the curding of the milk).

5th. The eruption of teeth with which to prepare solid food for stomach digestion.

Breast milk is the food that was intended to nourish the infant and at the same time promote this development. It is easy enough to prepare a substitute food that will contain as much *nourishment* as breast milk, but often such food causes digestive disturbance or fails to promote the normal development. Therefore substitute infant feeding calls for a careful study of each case to discover if possible why the substitute food is not succeeding. Sometimes it will be found that there is a deficient flow of digestive juices; in such cases food that can be absorbed with little digestive effort is indicated. At other

times the intestinal digestive juices will act, but the stomach is at fault; here food that can easily leave the stomach is indicated. Again, there may be poor absorption.

As any food that is not digested or absorbed will be found in the stools, an examination of an infant's stools will often show where the trouble lies, and is absolutely necessary if intelligent feeding is to be done, as food that would be indicated with one kind of stool might only aggravate the trouble if fed to an infant passing another kind. The napkins should also be examined to see if the urine leaves any stain, as a deposit of urates shows faulty metabolism.

Infant's Stools.

The normal infant stool is smooth, yellow, homogeneous, and of about the consistency of thin mush. The following may be considered abnormal types:

Curdy Stools.—Curdy lumps may consist of undigested casein or fat. The former are hard and yellowish, while the latter are soft and smooth, like butter.

Green Stools.—Stools can be considered green only when that condition is evident immediately upon their passage. They are thought to be due to a fermentation, which is doubtless the result of bacterial action. Certain drugs also produce green stools (27). Stools often become green a certain time after passage, caused by oxidation of the air.

Slimy or Mucous Stools.—These are the result of catarrhal inflammation. When the mucus is mixed with the fecal matter, the irritation is high up in the bowel, but when flakes or masses of mucus are passed, the trouble is near the outlet.

Bloody Stools.—The appearance of these stools will depend on the portion of the digestive tract that is affected. Small masses of dark clotted blood mixed in with fecal matter indicate that the seat of hemorrhage is high up, usually in the small intestine. When bright-red blood is passed, the seat of hemorrhage is low down, usually a little above the anal ring. Hard masses of casein may rupture the capillaries, or a fissure or polyp may be the cause of the bleeding. The appearance of fresh, bright-red blood in stools is more alarming than dangerous. The presence of dark clotted blood is of graver significance.

Yellow, Watery Stools.—These are seen in depressed nervous conditions, especially in the hot days of summer, when the bowel is relaxed and the inhibitory fibres of the splanchnic nerve do not act to advantage.

Very Foul Stools.—These are caused by decomposition of the albuminoid or proteid principles of the food (54).

Profuse, Colorless, Watery Stools, with little fecal matter, are doubtless caused by an infective germ, akin to that of Asiatic cholera. This condition is known as *cholera infantum.* The fluid consists largely of serum exuded from the blood-vessels, and the infant is quickly drained as if by a hemorrhage. This is often preceded by a few foul fecal stools.

It is rare to see one of these types by itself. With the exception of the last, they may be seen in all combinations.

Food for Infants with Normal Stools.

157. It is always best to *begin* by feeding young infants, every two hours, two ounces of a mixture of nine-ounce top milk with eight parts of diluent to which has been added one-twentieth sugar, as previously described (139), and watch the effect. If this is well borne, as shown by normal stools, absence of colic, and restful sleep, feed two and one-half to three ounces of a less diluted mixture, and follow this process until the feeding mixture is one-fourth nine-ounce top milk; then substitute sixteen-ounce top milk (136), and use one part with two parts of diluent, and finally equal parts of this top milk and diluent. When the top milk is less than one-third of the mixture, one part of sugar to thirty parts of food should be used. By this method the infant's digestive tract is gradually accustomed to digest the curds of cow's milk; *but not until a mixture that is one-third to one-half top milk is used does the infant get as much protein as a breast-fed baby.* This method of feeling the way along should also be followed when the infant is receiving part of its nourishment from the breast.

The percentages of fat in the infant's food may be decreased by diluting the top fourteen, eighteen, or twenty ounces from the bottle, instead of the top nine or sixteen ounces.

It is impossible to give exact quantities to be fed at different ages. All that can be done is to start with a general idea of the quantity required by the average infant at various ages. Begin with a weak mixture and work up as rapidly as possible to the point of toleration

in all cases (139). The graduate that may be used for measuring food (Fig. 65) shows *about* the stomach capacity at different ages, but it should be remembered that some of the food leaves the stomach almost as soon as

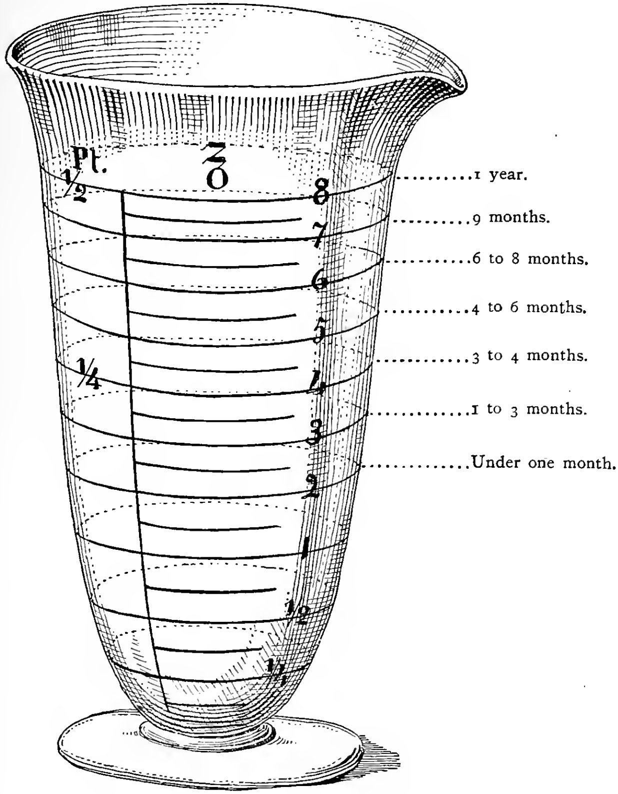


FIG. 76.—Approximate Stomach Capacity at Different Ages.

swallowed, so the size of an infant's stomach is not necessarily an exact measure of the quantity of food it should have at a feeding. Few young infants will be satisfied with a feeding no larger than the capacity of the stomach as measured by filling the stomach of a cadaver with water.

No infant should be left on a mixture containing less than one-fifth top milk for any length of time unless absolutely necessary, as the protein is too low in quantity. Here dextrinized gruels are of great value as diluents, as they increase the amount of protein in the infant's food, which is of great advantage (128).

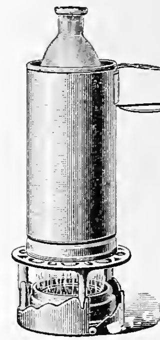


FIG. 77.—Baby Food Warmer.

158. Before giving the infant its bottle, the food should be warmed by placing it in warm water. A very convenient "Baby Food Warmer" is shown in Fig. 66. The heater is an alcohol stove which will warm an eight-ounce feeding in from three to five minutes. It is small enough to be carried when travelling.

Remove the cotton stopper from the bottle and fit on the nipple. Pure rubber nipples should be used. These will easily stretch several inches and resume their original shape; inferior nipples do not stretch easily. Invert the bottle and see that the hole in the nipple is large enough to allow the food to drop slowly, not run in a stream. Before feeding it is necessary to see that it is not too hot. A practical method of testing the warmth of food suggested by Marianna Wheeler consists in allowing a few drops to fall on the wrist. The nipple should never be put in the attendant's mouth. The infant should be held while nursing in as nearly the natural position as possible, and should not be allowed over twenty minutes in which to take food.

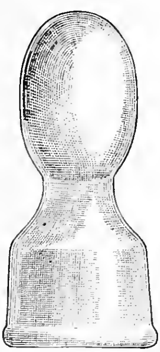


FIG. 78.—Nipple.

Regularity in feeding should be followed, and the hours at which feedings are to be given should be written down for the mother or nurse, as in breast feeding (114). Nothing but cooled boiled water should be offered between meals. It is well to remember that infants become thirsty.

The infant should be weighed each week and a record kept of its weight (173). Unless there is a steady gain in weight something is wrong. If the infant shows no signs of discomfort or indigestion, use a stronger food—that is, more top milk and less diluent. If there is indigestion and colic, the food will have to be changed as described in another place (161).

Fig. 79.—Bottle Brush.

If the infant is restless at night or if one feeding is vomited, it is well to substitute a feeding of the diluent (133), which will give the digestive tract a rest and at the same time maintain the infant's strength. This is especially beneficial in warm weather when the digestive function is depressed. When an infant vomits rancid curds shortly after feeding, use weaker top milk; that is, if nine-ounce top milk causes trouble, try sixteen-ounce top milk or even plain milk (132). This reduces the quantity of fat that becomes rancid in the infant's food. Sugar may also be reduced a half.

159. *Pasteurization of Food.*—When good fresh milk can be obtained, it is better not to pasteurize, as owing to the germicidal property of properly handled fresh milk little bacterial change will have taken place; but when the milk is of doubtful quality and freshness, the infant's food should be pasteurized as soon as made up (140). If the

milk reddened test paper (**139**), lime water, syrup of lime, or bicarbonate of soda (**133**) should be added to the food *after* pasteurization, until the reddened paper turns blue again.

Pasteurization has several practical effects. In the first place it alters the milk so that it is not easily acted upon by the rennet of the stomach, and curded. Secondly, it destroys acid-producing bacteria, which promote the action of the rennet ferment in very dense curds. Consequently, when there is great difficulty with the digestion of curds of milk, pasteurization of food may prove to be beneficial. It must be remembered that *old* pasteurized milk may prove to be very poisonous, so the food should be freshly prepared and pasteurized the day it is to be used.

The natural enzymes of milk are destroyed at about 158° F., but it is doubtful if they have any practical value as digestive aids, as it takes months for them to produce much change in the proteids of the milk outside of the digestive tract (**32 B, 61**).

Care of Nursery Utensils.

160.—After the food has been made up or the nursing bottles have been used, the dipper, measures, bottles, and anything that has had milk in should be first rinsed with cold water, then washed with hot water and soap or some of the washing powders, and a bottle brush. If hot water is used first, the milk "cooks on" the utensils, and it is then difficult thoroughly to clean them.

Cleanliness is a very important part of infant feeding, as dirty utensils may harbor bacteria (**59**) that cause decomposition in the food and hence produce sickness in

the infant. After washing with hot water the utensils should be boiled and the bottles either kept filled with water or inverted in a clean place until wanted for filling.

The nipples should be washed out and kept lying in a

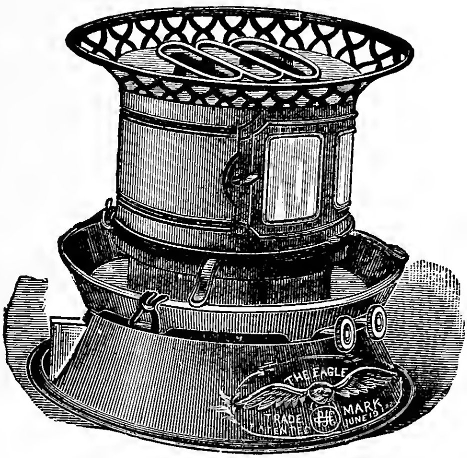


Fig. 80.—Oil Stove for Nursery.

cup of water in which a pinch of borax or boric acid has been dissolved.

To be sure of having a supply of boiling water, a gas stove or oil stove should be in every nursery outfit.

Summary of Feeding Instructions.

It is best to write out for the mother or nurse the formula to be used in making up food and the intervals of feeding, somewhat as follows, the quantities and feeding intervals being about as in the suggestive table (page 266):

Do not use one cow's milk. Get a quart bottle of good fresh mixed milk of a herd of cows from the dairyman, or if bottled milk cannot be obtained, place a quart of milk in a clean quart jar and set this on ice or in *cold* water until the cream has risen and appears as a layer at the top of the jar. This will take from four to six hours. When the cream has risen dip off the top . . . ounces; that is, all the cream and enough of the remaining milk to make . . . ounces, into a clean pitcher or bowl. Take from the milk in the *pitcher or bowl* . . . ounces and add . . . ounces of [water, barley, oatmeal or wheat flour gruel] and . . . ounces of sugar. (A level tablespoonful is half an ounce.) Divide this into . . . feedings . . . ounces each, in separate nursing bottles, and plug the bottles with tightly twisted clean cotton. Do not use corks. Keep the food on ice or in as cool a place as possible. Feed . . . ounces every . . . hours. Warm the food by placing the bottle in warm water *just* before feeding. Do not keep food warm to avoid the trouble of heating it. The food may spoil. After the cotton stopper has been removed and the nipple adjusted, the food should drop slowly when the bottle is held upside down.

Offer cool boiled water between feedings if the child appears hungry. If the food is not well digested, add one to two teaspoonfuls of lime water to each bottle. In warm weather heat the food, as soon as made, for twenty minutes in a double boiler and cool before putting into the feeding bottles, or buy a pasteurizer and pasteurize the food. Keep all utensils scrupulously clean and the nipples lying in a solution of borax when not in use.

Suggestive Table of Feedings.

Age one to four weeks.	Remove the top nine ounces from a quart of bottled milk into a pitcher or bowl. Of this milk in the pitcher or bowl use four ounces with thirteen ounces of water, or digested gruel, and one level tablespoonful of sugar. If there is difficulty in digestion, add one ounce of lime water to the mixture. Divide into nine feedings of two ounces each in separate nursing bottles and feed every two hours during the day and twice at night. As the infant grows older, one or two ounces more of the nine-ounce top milk may be added to the mixture.

SUGGESTIVE TABLE OF FEEDINGS.—*Continued.*

Age one month.	Remove the top nine ounces from a quart of bottled milk into a pitcher or bowl. Of this milk in the pitcher or bowl use seven ounces with nineteen ounces of digested gruel or water and two level tablespoonfuls of sugar. If there is difficulty in digestion, add one ounce of lime water to the mixture. Divide into nine feedings of three ounces each, in separate nursing bottles, and feed every two hours during the day and twice at night.
Age three months.	Remove the top nine ounces from a quart of bottled milk. Mix this with twenty-one ounces of digested gruel or water and three level tablespoonfuls of sugar. If there is difficulty in digestion, add two ounces of lime water to the mixture. Divide into eight feedings of four ounces each, in separate nursing bottles, and feed every three hours during day and once at night.
Age six months.	Remove the top twenty ounces from a quart of bottled milk and mix with twenty ounces of digested gruel or water and three level tablespoonfuls of sugar. If there is difficulty in digestion, add two ounces of lime water to the mixture. Divide into seven feedings of six ounces each, in separate nursing bottles, and feed every three hours during the day and once at night.
Age nine months.	Remove the top twenty-four ounces from a quart of bottled milk and mix with twenty-two ounces of digested gruel or water and three level tablespoonfuls of sugar. If there is any difficulty in digestion, add two ounces of lime water to the mixture. Divide into six feedings of eight ounces each, in separate nursing bottles, and feed every three hours during the day.
Age one year.	Whole milk, or, if not digested well, add one-quarter to one-third gruel. Amount in bottle, from nine to twelve ounces. Chicken, mutton, or beef broths, in same amount, may also be given.

If a higher amount of fat is desired in any of the latter formulæ, the top sixteen ounces from two bottles may be taken and mixed, and the same amount used as when the top twenty or twenty-four ounces from one bottle was employed.

CONDENSED TABLES.

Age.	Number of feedings in 24 hours.	Amount of feeding.	Intervals of feeding.	Ingredients.		
				Milk.	Diluent.	Sugar.
		Oz.	Hrs.	Ounces.	Ounces.	
1 to 4 weeks	9	2	2	9 oz. top milk: 2 to 6	13 to 17	1 level tablespoonful
1 month	9	3	2	9 oz. top milk: 7	19	2 " tablespoonfuls
3 months	8	4	3	9 oz. top milk: 9	21	3 " "
6 "	7	6	3	Top 20	20	3 " "
9 "	6	8	3	Top 24	22	3 " "
12 "	5	9 to 12	4	Whole milk, meat broths, pap, etc.		

An approximate method of removing the layers required from the quart milk bottle consists in carefully decanting the top milk. If this method is used, the top nine ounces will roughly represent the top third of the bottle, the top sixteen ounces the top half, and the top twenty ounces the top two-thirds of the bottle. The use of the author's dipper, however, is much more accurate and satisfactory, and any layer may be employed.

The following cut of milk bottle and dipper* will be helpful in making mothers understand what to do. Directions for making digested gruel will be found on page 236.

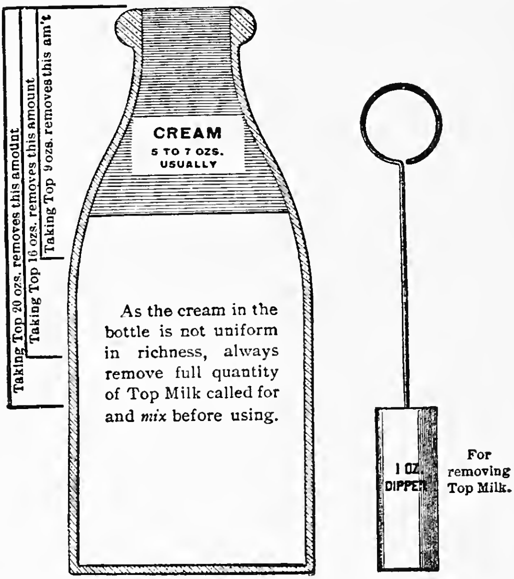


FIG. 81.—Quart Milk Bottle (Thirty-two Ounces) with Cream Risen. The first dipperful, or ounce, must be removed with a teaspoon, or the bottle will overflow; then dip from as near the surface as possible, as many dipperfuls or ounces as are called for into a pitcher or bowl.

If it is desired to make up any particular percentage mixture, as is often the case when a mother comes from

* The illustration and a nickel-plated dipper are furnished by the Cereo Company, Tappan, N. Y., for five cents, and an aluminum dipper by Jas. T. Dougherty, 411 West Fifty-ninth Street, New York, for twenty cents. They may be sent by mail.

another doctor with a percentage formula, as fat 3 per cent, proteid 1 per cent, sugar 6 per cent, the key to modification of bottled milk by Connors will enable a feeding mixture to be made up at once and the above directions can be used after the proper quantities of milk, diluent, and sugar have been determined.

Key to Home Modification of Bottled Milk.

AFTER J. F. CONNORS, M.D.

To make up any desired percentage mixture: (1) Look in the *proteid column* for desired percentage, using the one nearest to it. (2) Move in a horizontal line to the left until the desired percentage of fat is reached or one near it. (3) The heading of the fat column tells what kind of milk is to be used; and (4) the first column of the table what proportion of the feeding mixture the milk must be. (5) In preparing the food use good bottled milk on which the cream has risen. See Fig. 81. Dip off the proper milk and dilute all or part of it, depending on the quantity of food to be made up. Mixtures made from poor milk will be one-fourth weaker, from Jersey milk one-fourth stronger. (6) The *sugar column* shows the percentage of sugar in the diluted milk: one part sugar to 50 parts food adds 2 per cent; to 33 parts 3 per cent: to 25 parts 4 per cent; and to 20 parts 5 per cent. Two even tablespoonfuls of granulated sugar or three of milk sugar equal 1 ounce.

Proportions of Milk and Diluent in Feeding Mixtures.			Per Cent. Fat.								Per Cent Proteids.	Per Cent Sugar.
Parts milk.		Parts Diluent.	**Skimmed milk,** Fat about 1 per cent.	**Good whole milk,** Fat about 4 per cent.	**Top 20 oz.,** Fat 6 per cent (1½ times whole milk).	**Top 15 oz.,** Fat 8 per cent (2 times whole milk).	**Top 11 oz.,** Fat 10 per cent (2½ times whole milk).	**Top 9 oz.,** Fat 12 per cent (3 times whole milk).	**Top 8 oz.,** Fat 14 per cent (3½ times whole milk).	**Top 7 oz.,** Fat 16 per cent (4 times whole milk).	For skimmed, whole, or top milk, 3.25 per cent.	For skimmed, whole, or top milk, 4 per cent.
1	+	7	.13	.50	.75	1.00	1.25	1.50	1.75	2.00	.41	.50
1	+	6	.14	.57	.86	1.14	1.43	1.71	2.00	2.30	.46	.57
1	+	5	.17	.67	1.00	1.33	1.67	2.00	2.34	2.67	.54	.67
1	+	4	.20	.80	1.20	1.60	2.00	2.40	2.80	3.20	.65	.80
1	+	3	.25	1.00	1.50	2.00	2.50	3.00	3.50	4.00	.81	1.00
1	+	2	.33	1.33	2.00	2.67	3.33	4.00	4.66	5.33	1.08	1.33
2	+	3	.40	1.60	2.40	3.20	4.00	4.80	5.60	6.40	1.30	1.60
1	+	1	.50	2.00	3.00	4.00	5.00	6.00	7.00	8.00	1.63	2.00
5	+	3	.62	2.50	3.75	5.00	6.25	7.50	8.75	10.00	2.03	2.50
2	+	1	.67	2.67	4.00	5.33	6.67	8.00	9.33	10.67	2.16	2.67
3	+	1	.75	3.00	4.50	6.00	7.50	9.00	10.50	12.00	2.44	3.00

Food for Infants with Colic, Persistent Vomiting, Abnormal Stools, and Evidence of General Malnutrition.

161. *Colic* may be caused by an excessive quantity of proteid in the food or by the infant not being kept warm enough, especially the bowels and extremities. The excess of proteid in the food may be reduced by increasing the dilution. *Persistent vomiting* may be caused by feeding too great a quantity at a time; from too much fat or cream in the food, or by poisonous products in the milk, the result of bacterial growth. *Abnormal stools* may contain curds of casein or fat, fermenting sugar, and mucus resulting from the undigested food irritating the intestine. Digestion is at a standstill and the infant is living partly on its own tissues, hence the malnutrition.

As all these conditions are often seen at the same time, it is not always practical readily to discover the cause of the digestive disturbance. This belongs more to research work than to practical infant feeding. The problem for the feeder is to nourish the infant and re-establish the digestive process. Here the natural order of development (156) can be followed with advantage:

1st. If the stools show signs of fermentation or putrefaction, clear out the intestines with a mild purgative (see Summer Diarrhœa) (170).

2d. Supply nourishment that will be absorbed with little digestive effort and spare the infant's tissues.

3d. When the stools become normal, gradually add food that will stimulate the flow of digestive juices and develop the functions of the stomach.

162. When milk feedings cause digestive disturbance as just described, it is best to stop them at once and feed gruels, dextrinized gruels, or egg-water (137); these will generally be retained and assimilated, and furnish considerable nourishment. When the digestive disturbance has subsided, a *teaspoonful* of plain milk may be added to a two-ounce feeding and the quantity gradually increased and sugar added as fast as the infant's digestion will permit. In this class of cases the addition of lime water or syrup of lime until the food is alkaline to litmus paper may be beneficial; one part of lime water to twenty parts of food is often used. It should be remembered that the syrup of lime is about thirty times as strong as lime water; hence one teaspoonful of syrup of lime equals about four ounces of lime water.

163. Occasionally infants will be met who cannot digest the casein of cow's milk without constant difficulty and distress. The shifting of percentages or altering the diluent appears to make little difference in these cases, as the infant continues to fret and to show a stationary or losing weight. This may be the culmination of many attacks of indigestion, or sometimes it seems to be sort of gouty or lithæmic heritage, perhaps coming directly from the parents, and showing itself in such a form at this early age. After a fair and intelligent trial of ordinary cow's milk has proved unsuccessful, it is best to put the infant on condensed milk. The process used in condensing appears to produce a change in the casein that makes it easier of assimilation in this class of cases. Fresh condensed milk is preferable, but when this cannot be obtained the best brands of sweetened condensed milk may

be used. Sometimes it is necessary to use as little as one teaspoonful to four ounces of plain or dextrinized gruel (137) at the start. If this is well borne the quantity of condensed milk should be rapidly increased. After the dilution has reached one to fifteen, equal parts of condensed milk, and cream removed from a bottle of milk, and mixed, should be used for dilution, which may be reduced gradually to one to five or six parts of diluent (composition about two to three per cent fat, one to one and one-half per cent proteid, six to eight per cent sugar).

164. When only small quantities of food can be digested, one teaspoonful of beef juice (152) may be added to a two-ounce feeding. This is slightly nourishing and acts as a digestive stimulant (13). Occasionally when highly diluted milk is not well digested a much smaller quantity of more concentrated milk food will be retained and digested, or peptonized milk (147) may succeed.

When milk of any kind is not tolerated, white of egg and dextrinized gruel or yolk of egg with the same (149) may be tried. Occasionally dextrinized gruel will not be tolerated. Then resort may be had to whey, meat broths, or white of egg in water (148), getting back to milk feedings as soon as possible, always bearing in mind that the aim is to have the infant ultimately take between three and five per cent of fat, one and two per cent of proteids (mixture one-third to one-half top milk), and five to eight per cent of sugar.

Only general rules can be given for feeding these cases. They may be summarized as follows:

1. Maintain nutrition with any form of food that will

be readily absorbed (dextrinized gruel, whey, egg mixture).

2. When the stools become normal, give food that will gradually re-establish the digestive process (add small quantity of milk).

3. Return to milk feeding (139) as soon as possible.

4. The fact that all the food that is utilized combines with the oxygen of the air we breathe should not be overlooked, and hence attention should be paid to the air supply as well as to the food.

It should be remembered that fats retard gastric secretion, and that excess of sugar promotes the flow of an acid gastric juice; therefore these ingredients should be reduced in quantity when there is gastric disturbance. Excessive vomiting may be due to mucus in the stomach, which may be removed by stomach washing (165); or to nephritis. In all forms of fevers, fats should be reduced in quantity, and easily assimilated carbohydrates in the form of dextrinized gruels (137) supplied along with milk, to reduce as much as possible the excessive destruction of protein tissues that takes place in fevers (13, 14, 19, 25).

CHAPTER XXIV.

FEEDING BY GAVAGE—NASAL FEEDING—RECTAL FEEDING—FEEDING PREMATURE INFANTS.

165. Cases are not infrequently met with in which an infant cannot or will not take sufficient nourishment by swallowing. It will then be necessary to feed wholly or in part by the stomach tube. This proceeding is often easier than it looks; all that is needed is a glass funnel, to which is attached a short rubber tube, and this to a soft catheter, by a short piece of glass tubing placed between the rubber tube and catheter, so that the flow of the fluid can be seen. The infant is placed in a recumbent position, with the arms bandaged to the sides of the body or fastened by a towel tightly pinned around; an assistant steadies the head, and the tube is quickly passed through the mouth; when it reaches the back wall of the pharynx a little force is required to deflect it downward, when it is easily passed into the stomach. In cases in which the tonsils are much swollen, as in diphtheria, the tube may be passed through the nostril, taking care to pass the tube through the inferior meatus along the floor of the nose. It is sometimes a little more difficult to get the tube through the nose, besides being apt to cause more discomfort. Fluid will flow more readily when the tube is full as it passes into the stomach. Otherwise the column

of air in the tube may offer some resistance to the flow of the nutrient fluid. This can be obviated by filling the tube with warm water or the fluid food, and then pinching the tube just below the funnel. The fluid will then not run out of the tube, which can be passed into the stomach; when it is in place the funnel is filled, after which the grasp on the tube is relinquished, and the fluid will easily flow into the stomach. When the tube is withdrawn, it should be pinched again to prevent drops trickling out and irritating the pharynx, as vomiting may be caused by such irritation.

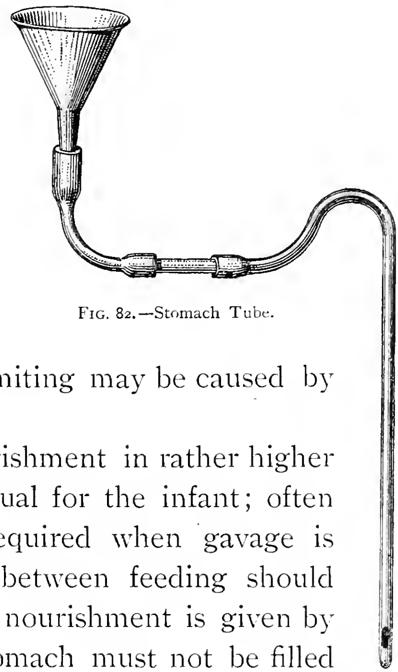


FIG. 82.—Stomach Tube.

It is better to give nourishment in rather higher dilution than has been usual for the infant; often partly digested food is required when gavage is employed. The intervals between feeding should also be longer than when nourishment is given by natural means, and the stomach must not be filled too fast. Where gavage is continually employed, the stomach should be washed out every day or so with warm water before feeding, as, by removing mucus or particles of food, digestion and absorption are improved.

In stomach washing, pour in water through the tube as in feeding. Then lower the funnel so that the water can siphon out of the stomach.

Premature infants and atrophy cases at term may

sometimes be fed to advantage by gavage; also harelip or cleft-palate babies, who swallow with difficulty; and after certain operations upon the mouth. Some badly nourished babies absolutely refuse to take sufficient nourishment, which may be corrected by the use of the stomach tube. The author has seen cases in which one or two full feedings thus given was followed by the baby voluntarily taking a proper amount. In meningitis, and when there is complete or partial unconsciousness from any cause, gavage may be employed with good results. The same may be said of diphtheria accompanied by much swelling of the throat, and particularly after intubation. In the latter case, feeding by gavage should always be employed, at least for the first day or so. Later on the child may be cautiously spoon-fed with the head in a low position, and viscid substances, like condensed milk, are less apt to penetrate the tube. Finally, persistent vomiting is sometimes relieved by one or two feedings by gavage. When the stomach tube has been used for any cause, the child should be kept very quiet in a horizontal position for some time afterward; the chance of vomiting will thus be much lessened.

Rectal Feeding.

166. There is a great difference in the tolerance of the rectum to attempted feeding in the infant as in the adult. At times, such as in extreme gastric irritability or when there is local obstruction, as in diphtheria or retropharyngeal abscess, it is often desirable to stop for a time all nourishment by the mouth. In such cases we must bear in mind the fact that the rectum can absorb but not digest food, and that small amounts will often be retained

when larger amounts are rejected. The lower bowel must first be cleaned by a moderate injection of warm salt solution or soap suds and water. From one to two ounces of the nutrient solution may then be very slowly injected, with the buttocks slightly raised and tightly held on either side of the nozzle of the syringe. When the nozzle is withdrawn the buttocks had better be held in close apposition for a few moments, to prevent a leaking out of part of the enema. In cases in which the rectum is intolerant, a very small amount, such as two or three drachms, will sometimes be retained. The occasional addition of a fraction of a drop of deodorized tincture of opium to the nutrient enema will help to quiet an over-irritated rectum, but the susceptibility of very young infants to the constitutional effects of opium must always be borne in mind. When the enemata are given at regular intervals, the preliminary washing need not be employed after the first time, as this increases the irritability of the bowel. Easily absorbable nutriment must always be employed, such as dextrinized gruel, dextrinized gruel with white of egg (149), completely peptonized milk, or expressed beef juice and water. In cholera infantum, where the quick loss of fluid from the blood-vessels threatens life, the injection of a hot saline solution into the bowel sometimes affords relief. Here again a small amount is often preferable, as two or three ounces, or even half an ounce, may be retained and absorbed, when a pint may be quickly rejected.

FIG. 83. — Rectal Syringe.

Feeding of Premature Infants.

167. The difficulty of nourishing premature babies consists in the incomplete development of their digestive tract, and the difficulty of keeping them warm while at the same time supplying sufficient fresh air. They are exceedingly dependent upon pure air, and here it is that most incubators fail. The author has treated over fifty premature infants in incubators at the Babies' Wards of the New York Post-Graduate Hospital, but with poor results. This is attributed to two factors—the absence of the breast, calling for exclusive artificial feeding; and the delay in getting them, many of the babies being blue and cold from exposure in transporting them to the hospital when received. The author has tried all kinds of incubators, and believes that only those having a fresh-air inlet connected with the outer air are safe to use. The Lyon incubator is a good example of this type. If such an incubator is not obtainable, an ordinary soap box may be improvised, in which the baby is placed, done up in cotton and surrounded by hot-water bottles. The top of the box may be partially covered with a sheet or towel, so arranged as to allow free access of fresh air. The babies at first seem to do best at an average temperature varying from 85° to 90° F. The less the infant is disturbed the better; at the same time proper cleanliness of the baby and incubator must be insisted on, as these infants are very vulnerable to infection of all kinds. The most important factor in raising them is to secure breast milk. The milk must be drawn from the breast after the colostrum period, the preferable time being from about eight

days to a month or so post partum. This milk must usually be diluted one-half with boiled water or sugar-water solution. The best way, in the author's experience, to administer fluid to these babies is by means of a medicine dropper. This must be done very slowly, drop by drop, taking care to see that the motion of swallowing is accomplished after each drop before giving another. This extra care is required from the tendency of the fluid to get into the windpipe. The author has seen a number of deaths from this cause, as shown by autopsy.

When the infant is too feeble to swallow, a small catheter used as a stomach tube must be employed. It can be passed without removing the baby from the incubator, and does not seem to cause it much disturbance. As soon as the baby grows older and is strong enough, a small nipple may be substituted. The exact amount to be given a premature baby must depend upon the period of utero-gestation and its apparent development. In one case, weighing only two and a half pounds, a drachm every hour was given by the author, with good results. In better-favored cases, from four to eight drachms can be given every hour or two. If the infant thrives, in two or three weeks it can be given pure breast milk at two-hour intervals. Where it is impossible to get breast milk the chances of the premature baby will be very poor, but efforts must be made in the line of artificial feeding. Both the fat and proteids of cow's milk are digested with difficulty in these cases, so they must be given in very small amounts. The milk must be diluted to represent fat 1 per cent, sugar 3 per cent, proteids 0.33 per cent (one-tenth nine-ounce top milk plus one-thirtieth sugar),

of which a drachm may be tentatively given every hour; if tolerated, gradually increase the amount. If the baby is at the eighth month, a little stronger mixture may be borne, such as fat 1.5 per cent, sugar 5 per cent, proteids 0.50 to 0.75 per cent (one-eighth to one-fifth nine-ounce top milk plus one-twenty-fifth sugar). Such a case may take from four to six drachms every hour and a half. The exact amount must depend upon the general development of the baby, bearing in mind that the stomach of the baby at term has a capacity of about an ounce. Some cases cannot digest ordinary cow's milk, and then a trial may be made of whey, expressed beef juice, egg water, or highly diluted condensed milk. In a case recently seen with Drs. Hurlburt and Sherill, of Stamford, Conn., a feeble incubator baby was successfully fed with undiluted ass' milk for about a month, gaining in weight and strength. This milk then giving out, the baby was put on a wet-nurse and continued to thrive.

CHAPTER XXV.

CONSTIPATION.

168. Constipation as well as diarrhœa are relative terms, and refer more to the character than the frequency of stools. A constipated stool in an infant is usually dry and hard and voided with some difficulty. One or two such stools may be passed daily with evidence of intestinal discomfort, and call for dietetic treatment. In the nursing infant the mother is herself frequently constipated, and treatment must first be directed to her, as when she is properly regulated the infant may need no further attention. Stewed fruit, figs, prunes, oatmeal and cream, unbolted bread, and similar articles of diet may be tried with the mother, with plenty of outdoor exercise. It may be necessary to cut off milk in part, or to give it diluted with oatmeal gruel to which cream is added. A glass of cold water or Vichy immediately upon rising has a favorable effect in opening the bowel. Tea should be avoided. If these measures do not suffice, some of the tonic laxatives, such as cascara, aloin, nux vomica, and hyoscyamus may be tried. The commercial mixtures of malt extract and cascara are usually efficient and agreeable.

When the mother has been regulated and the infant remains constipated, there is usually a deficiency of fat in her milk, often accompanied by a high percentage of proteids. If this cannot be corrected by a meat diet and

plenty of exercise (20), a little fat may be administered to the baby just after nursing. A small teaspoonful of cream two or three times daily given in this way may correct the infant's constipation; a half-teaspoonful of sweet oil will also serve the same purpose. The efficacy of the oil is sometimes increased by combining with it a little sugar and water, a small lump of loaf sugar being dissolved in a teaspoonful of water and given with the oil. A half teaspoonful of cod-liver oil may also be employed in the same way.

The nursing baby may be constipated from the mother's milk being deficient in both fats and proteids, or from an insufficient quantity of it. If efforts to correct this condition fail, it may be necessary to supplement the breast by the bottle in order to increase the volume of the stool (27) and thus relieve the constipation. As a rule, bottle-fed babies are more apt to suffer from constipation than those on the breast. In the former cases the condition may be corrected by increasing the fat in the feeding mixture. According to the dilution often recommended for young babies, the fat barely reaches two per cent when poor milk is used in making the mixture. By using less diluent or a richer top milk (132), we may run the fat up to three per cent and thereby improve nutrition as well as relieve constipation. During the first six months or so of the first year the baby usually thrives best on a mixture containing three per cent fat and one per cent milk proteids, while later in the year four per cent fat and one and one-half to two per cent milk proteids are indicated (143). The neglect to administer percentages suitable to the age and condition of the infant is responsible for a

good deal of constipation, a habit it is sometimes difficult to correct even when the cause is removed. A change in the diluent employed will sometimes be necessary; if gruels are used, oatmeal is more laxative than barley or wheat flour. Infants of a year old may be given chicken tea, which is somewhat laxative, and beef tea may have the same effect; expressed beef juice sometimes favors an action of the bowels. A teaspoonful to a tablespoonful of orange juice given in the morning often has a laxative action upon the infant. The free use of water, between nursings or feedings, tends to prevent too great consistency of the stools, one of the common accompaniments of constipation.

For children of two or three years, fresh fruit, such as apples, peaches, and oranges, may be given in the morning; stewed fruits of all kinds are allowable, and dried fruits, such as prunes, figs, and dates, often do good service. The following method of treating prunes, given the author by Dr. Cauldwell, has often produced favorable results: Fill a preserve jar one-half or three-quarters full of fresh California prunes, and pour in boiling hot water to fill the jar; next close the jar and stand in a warm place for six or eight hours. During this time the prunes become full and swollen and the pulp is very soft. The water is then drained off and the prunes are spread on a plate so that the skins may dry quickly. They are now ready to eat; split open and use the pulp only. Give the pulp of three to six prunes before breakfast each morning with a glass of cold water. The laxative effect of the prunes is thus much enchanced, and they are usually readily taken in this form by children.

Crandall has stated that for constipated babies it is a good plan to give prunes that have been boiled with a few senna leaves.

The following "Fruit Tablets" are agreeable and efficacious: Take four ounces each of raisins, figs, and dates, and two ounces of ground senna leaves; remove the seeds from the raisins and dates, and finely chop the fruit; then mix on a table, adding the senna to the chopped fruit little by little, putting in sherry enough to make a paste; roll into a mass half an inch thick, and cut into half inch squares; place the tablets between sheets of paraffin paper in a box. One or two of these tablets may be given at night and repeated in the morning if necessary to get the result.

It may be desirable to curtail the milk in cases of obstinate constipation or to add cream to what is taken. The coarse cereals, such as oatmeal, unbolted bread, and all the green vegetables, may be given at two years. These foods, by their saline and fibrous contents, have a stimulating effect upon the mucous and muscular coatings of the intestine, and increase the quantity of fecal matter (27).

Very often the trouble consists in a sluggish action of the unstriped muscular fibres of the bowel, which suitable diet is not sufficient to correct. Deep massage of the bowel, beginning at the right iliac fossa and extending around the course of the large intestine, may aid muscular action if thoroughly performed twice daily. The use of suppositories and injections also stimulates the muscles to more vigorous action. For occasional use, glycerin suppositories are very efficient, but if employed too fre-

quently are apt to irritate the rectum. For continued use, gluten or soap suppositories serve best. The fault in constipation of young infants is often at the lower end of the large intestine. Owing to the length of the sigmoid flexure during infancy, this part of the bowel is sharply curved, with a resulting tendency to retard the descent of fecal matter just above the outlet of the bowel. A bland suppository, or even passing the end of a finger through the anal ring, will often cause the bowel to empty itself. The passage of a healthy digested stool after such a manipulation will prove that there is no essential fault in diet or digestion, but simply a sluggishness at the end of the bowel. If fecal matter is higher up, an injection of two or three ounces of soap suds and water, salt and water, or sweet oil and water will be required for relief. In obstinate cases a teaspoonful of glycerin in an ounce of water will usually have a quick effect.

A constipated infant should be constantly observed and treated until the condition is relieved, as most of the chronic cases in later life have their beginnings in early life. No structure of the body is more amenable to habit than the bowel; hence the importance of starting right. As soon as the baby can stand, it should be placed upon the chair or chamber at regular intervals. Yale has called attention to the importance of placing the child upon a low seat with the feet upon the floor, as it can then strain to better advantage.

CHAPTER XXVI.

SUMMER DIARRHŒA.

169. The cause of the diarrhœal diseases of infancy so common during the summer months is not positively known, though there can be little doubt that they are of bacterial origin. Just where the bacterial infection originally takes place is hard to tell, although in many cases it is undoubtedly local. It has been generally believed in the past that the high temperature of the summer months was the cause of the diarrhœal epidemics. Heat does play an important part, especially in depressing the digestive function, but in the summer of 1901, which was an exceptionally hot one, the number of deaths from diarrhœal diseases of infants throughout New York State, outside of the district including Greater New York and its suburbs, was only a little over half of that of the previous summer, which was not so hot. The amount of rainfall also seems to have little or no effect on the number of deaths from diarrhœal diseases of infancy.

The milk supply has come in for its share of condemnation as the principal cause of diarrhœal diseases; undoubtedly the milk supply is a prominent factor, but there must be still other sources of infection, as breast-fed infants are sometimes attacked.

If the milk supply was the exclusive cause of the disease, there should be a larger proportionate number of

deaths in cities like New York, whose milk is twenty-four to forty-eight hours old when received, than in the country where the milk is produced. New York's milk supply is drawn from a wide range of country, but it is found on examining the death statistics that in some years there is a great increase in the number of deaths in the country districts where the milk is produced, and only a slight increase in Greater New York; in other years an increase in the country and a falling off in the city is found, as will be seen by the following figures obtained from the New York State Board of Health:

Deaths from Acute Diarrhœal Diseases, May 1st to November 1st, Inclusive.

	1892.	1893.	1894.	1895.	1896	1897.	1898.	1899.	1900.	1901.
Country districts..	2,550	2,721	3,046	2,727	3,039	2,086	2,833	2,187	3,202	1,898
Greater New York and suburbs....	5,943	5,477	5,244	5,559	4,908	4,340	4,868	3,557	3,867	6,115

It is improbable that there is enough variation in the methods of handling milk from year to year to account for this fluctuation in the number of deaths. There must be some local infection. In 1901 the Borough of Manhattan of the city of New York was torn up from one end to the other for the purpose of building a subway. Sewers were opened and changed, and dust was everywhere. In the country districts, where the milk was produced, there was a large falling off in the number of deaths from diarrhœal diseases, as previously mentioned, while in the district which included Manhattan the number of deaths was almost double that of the previous year. It is evident that there must have been a local infection that caused this (62).

At the Wisconsin Experiment Station there has been worked out what is known as a curd test, by which the

Fig. 84.—Rennet Curd of Milk when Lactic Bacteria Predominate. (Russell.)

character of the bacterial changes in the milk may be determined and the source of the infection located.

A sample of milk is curded by rennet, and the whey which contains most of the sugar of the milk drained off; the curd is then kept at a temperature of about 100° F. for several hours.

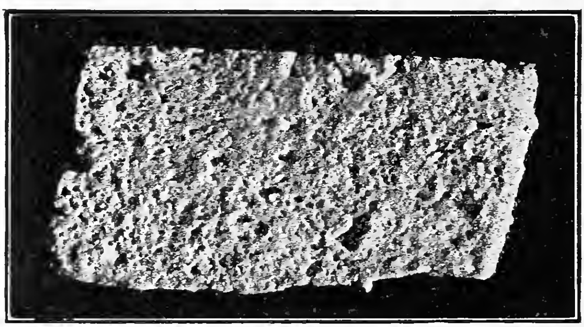


Fig. 85.—Rennet Curd of Milk when Gas-Producing Bacteria Predominate. (Russell.)

The normal fermentation of milk is souring, in which the sugar is changed into lactic acid by lactic bacteria;

when this change takes place the curd becomes firm and uniform in texture. However, if decomposition or other kinds of bacteria that attack proteids (54) are present, they find favorable conditions for growth in the curd which contains little sugar, and soon outstrip the lactic bacteria in growth (52). Their presence is shown by the production of gas, which causes the curds to rise like bread dough, or in foul offensive odors resulting from the decomposition of the proteid of the curd.

Both of these abnormal fermentations are very common in milk during July and August, the months in which there is generally the greatest number of deaths from diarrhœal diseases.

At cheese factories these bacterial changes are particularly troublesome, and a great deal of time and study has been devoted to locating the source of the infection. The curd test has proved to be valuable for this purpose. By making a curd from the milk of each farmer and rejecting the milk that produces gassy or foul curds, it has been possible to overcome the trouble. By following this same method with the milk of each cow, it has been possible to discover the infectious material, which is almost invariably dust or filth. It has been found that no matter how much care has been devoted to producing the milk, if it becomes slightly infected with dust or filthy water that contains these bacteria, they will rapidly grow and elaborate their characteristic products.

In cases of summer diarrhœa there is generally a great deal of gas formed in the intestine, and many thin, sour stools containing undigested curds of milk are passed. In some instances the stools which contain undigested

curds are few but very foul and offensive, indicating a decomposition of proteids. Here are seen all the changes that result from dust and filth infecting milk.

For this reason not only must care be exercised in the production of milk at the farm, but it should not be opened until delivered to the family; and in the family care should be used to keep all utensils absolutely clean. Pasteurizing the food is one step toward preventing the growth of these bacteria; but, if they gain access to pasteurized food or milk, they grow even better than in fresh milk. Koplik has called attention to this question and to the necessity of the mother or nurse carefully washing her hands after changing an infant's diapers, as she may easily infect the nipple or the food in this manner. The soiled napkins should be immediately placed in a saturated solution of chloride of lime and allowed to soak before being washed.

There can be little error in concluding that contamination at the farm is an important factor in infecting the milk; also that dust, contaminated water, soiled hands, and possibly flies at the home are also dangerous. The greater or less infection of the milk from these sources after leaving the farm is the probable cause of the variation in deaths from diarrhœal diseases from year to year in city and country.

Nature of Summer Diarrhœa.

170. The discovery that the dysentery bacillus of Shiga was present in the stools of infants suffering from summer diarrhœa led to the belief that this bacillus was the cause of the disease, and great hopes were entertained

of producing an antitoxic serum for use in treatment. Very careful studies have shown that there are at least two different kinds of dysentery bacilli and that there must be a serum used for each kind; as yet no satisfactory serum has been made. La Fetra and Howland have reported a clinical study of sixty-two cases of infection with bacillus dysenteriæ (Shiga) occurring in breast-fed and bottle-fed infants.

No clinical picture that is peculiar to this infection was discovered. The symptoms ranged from those of simple intestinal indigestion to those of acute summer diarrhœa. One thing prominently brought out was that well-nourished infants that had good digestion were the least affected, while those who were poorly fed artificially had the most severe symptoms. Twenty per cent of the cases were breast fed, but "not one of them was severely or even moderately ill." Properly nourished infants will not be very susceptible to these infections, and, if attacked, will with proper eliminative and dietetic treatment be able to produce their own natural antitoxins, which is desirable in view of the fact that each bacillus calls for its own specific antitoxin.

There seem to be bacteria present in the digestive tract at all times, but their growth is retarded or at least not harmful when digestion proceeds normally. During the heated term all the vital functions are depressed and digestion proceeds slowly. The milk curds in the stomach normally, and the whey containing the sugar is expressed (37). If fermentation instead of digestion takes place, the lactic bacteria have a free field in the whey, and the putrefactive or gas-producing bacteria

in the curds, where they are protected from the action of what little digestive juice is secreted. Products of proteid decomposition resulting from such conditions are apt to be poisonous (54), and it is not at all uncommon to see all the symptoms of toxæmia in infants and children with diarrhœal diseases, especially when the stools are offensive. Therefore these diarrhœas should be looked upon as cases of indigestion with a digestive tract filled with fermenting and putrefying food.

As previously stated (169), the cleanest milk or pasteurized milk is quickly rendered harmful by only a slight contamination with this putrefying material; it is therefore worse than useless to put any more milk or other food that will putrefy into such a digestive tract as long as this putrefying material remains. It would only aggravate the trouble. The diarrhœa is an attempt of nature to get rid of the offending matter.

The treatment of this disease consists of giving a mild purgative thoroughly to remove the putrefying intestinal contents, and then re-establishing the digestive process. To many mothers the giving of a purgative to an infant with diarrhœa seems folly, but it is absolutely essential to successful treatment, and if the mother cannot be trusted to give it, the doctor should do so himself.

During an attack of summer diarrhœa the infant's food should be carefully looked after. The promptness of recovery will depend largely on this, for as soon as the digestive process ceases, owing to the infection, the infant begins to live on its own tissues and there is a great and sudden increase of protein metabolism, as the protein is used as a fuel. In infants that have been on a diet poor

in protein this is particularly disastrous, as they have little reserve protein to draw on. Such infants quickly succumb.

The aim in feeding should be to sustain the infant by the use of food (1) that will not form a culture medium for putrefactive bacteria, and (2) that will prevent the abnormal destruction of protein tissue, which is especially large where there is fever. For this purpose carbohydrates stand pre-eminent, and in the author's experience gruels, especially when dextrinized (137), are the best forms in which to give them. These contain a small quantity of protein in a form that will not easily undergo putrefaction, and enough carbohydrates in a form suitable for prompt absorption to sustain the infant and prevent its own tissues being destroyed to any extent. Much more nourishment can be given in the form of dextrinized gruels than in plain cereal waters. If any fermentation takes place in this food, poisonous products are not formed, as carbohydrates predominate, which bacteria change into lactic acid, that is not harmful. When dextrinized gruels cannot be had, egg water (148) may be used, but this supplies only about one-fourth as much nourishment as the dextrinized gruel. The products of egg metabolism, principally urea, must be excreted by the kidneys, which are often congested and irritated by the toxins absorbed from the intestinal tract; and, in addition, by the urine, which is concentrated and scanty, owing to the large loss of fluid from the bowels. The products of carbohydrate metabolism pass off through the lungs.

White of egg is a pure protein substance and should

be used cautiously when the stools are foul, but may be used freely when they are very sour (52).

Kerley, after studying several hundred cases of summer diarrhœa, came to the conclusion that on a carbohydrate diet there was less systemic poisoning, recovery was more prompt, and temperature lower than on a protein diet.

Treatment and Diet in Summer Diarrhœa.

171. First: Clean out the digestive tract by doses of castor oil (one teaspoonful) or divided doses of calomel (one-tenth grain every hour until one grain has been taken). If the stools are few and foul, the bowel should be irrigated with a quart of tepid salt solution (one teaspoonful to a quart), to hasten the removal of the putrid matter. A fountain syringe with hard-rubber tube should be used, and the water allowed to flow in gently until it runs out clear.

Second: Stop all milk food of *any kind*, and offer boiled water; if this is retained, feed the same quantity of dextrinized gruel or egg water (137) as the usual milk feeding, at two-hour intervals. Rice is one of the best cereals for this purpose, as it is absorbed almost completely. Rice flour or one of the flaked-rice preparations (102) may be used in preparing the gruel, as these can be cooked in a few minutes. Barley and wheat flour come next in order. If the gruel produces sour acid stools, try egg water (148) or mutton broth (154). *When the stools become normal, a teaspoonful* of milk should be added to a feeding of the gruel, and the quantity cautiously increased until the usual mixture is taken. Often not a drop of milk will be tolerated for a long time. In these

cases a strong dextrinized gruel may be used for nourishment, and to prevent the infant tiring of it, barley, rice, or wheat may be used alternately. Mutton broth (154) or beef juice (152) may be added in small quantities to act as flavoring agents and promoters of digestive secretion. Care must be exercised in giving meat broth or juice in these cases. Dorning has called attention to severe ptomain poisoning from the use of beef juice made from tainted meat; and in too large quantities the meat extractives (13) have a decidedly laxative effect.

Drugs to be Used.—Subnitrate of bismuth is the principal one used, aside from castor oil and calomel. It should be given until the stools become black. Opium has its place, but should not be used before the intestine has been thoroughly cleared. Alcohol may be used up to the point where it can be detected in the breath in cases of great prostration, but many mothers are apt to give too much, which interferes with digestion and also throws additional strain on the kidneys in excreting it.

Preventive Measures.—Fresh air, cool sponge baths, and light diet are good preventive measures. The author often advises allowing the smaller children to play in a bathtub containing tepid water daily in hot weather. Care should be exercised in having the abdomen kept warm at night with a light flannel band when there are apt to be sudden changes of temperature, as cold may be the starting-point of summer diarrhœa.

CHAPTER XXVII.

DIET DURING SECOND YEAR.

172. The diet during the second year requires careful consideration, as this is a period of transition between the breast or bottle and the ordinary mixed diet of later childhood. It is a time of rapid growth, with cutting of teeth, when new functions are inaugurated, all of which require watching. The common mistake in feeding is to allow too great a variety, thus taxing the digestive powers at a time when they can ill afford to be strained. Cow's milk must still form the basis and most abundant article of diet.

The cutting of teeth indicates that the *chemical* portion of the digestive process (5) has been established and that the mechanical function (5) is being developed. The infant is prepared chemically to change many of the articles of diet that the mother eats, but it cannot yet prepare them so that they will be acceptable to the digestive tract. Meat should be finely divided before being swallowed, and until a full set of teeth is provided for this purpose the dividing must be done by the nurse or mother.

The nutriment of vegetable substances is enclosed in cellulose (10), which even the mother cannot digest except to a slight extent. Therefore vegetable food for infants must be well cooked to burst open the indiges-

tible cells. For this reason only tender vegetables or cereals should be used. A clear idea of the difference between vegetables in this respect may be had by tasting the tender tip of boiled asparagus and the woody butt of the stalk. All vegetable substances for infants and children should be cooked until they are as tender as asparagus tips.

Fruits of various kinds are early allowable, such as orange juice, apple sauce or baked apple with the skin removed, stewed dried apples, and stewed prunes after the pulp has been squeezed through a sieve. These articles are not only digestible, but have a favorable action on the bowels.

At the end of the first year we may start with one soft, semi-solid meal during the day, this to take the place of one bottle. As the infant grows and shows an ability to digest this kind of food, a second similar meal may be substituted.

A thin pap, made by soaking stale bread crumbs or zwieback in hot water and adding this to milk, affords a good beginning for spoon food. A fresh egg (113) boiled for two minutes and thoroughly stirred with bread or cracker crumbs is likewise generally relished. The cereals cooked to a *jelly*, salted, and covered with milk make a very good meal. From a nutritional standpoint oatmeal is to be preferred, but some infants seem to object to its taste. If when it is used there is a tendency to intestinal fermentation or irritation of the skin, it had better not be employed. The higher grade of rolled oats sold in packages should be selected, as they contain less husk, which is irritating to the intestines. While ordi-

nary oatmeal requires many hours of cooking (102) these rolled oats can be thoroughly cooked by half an hour's boiling in a covered double boiler if plenty of water is used, so that each particle of oat becomes soaked before the boiling temperature is reached.

Sometimes an infant will readily take one cereal while rejecting another, or will tire of one preparation after a certain amount of use, and hence require a change. Among the better known prepared cereals that may be used are Quaker Oats, Hornby's Steamed Cooked Oatmeal, Germea, Pettijohn's Breakfast Food, Wheatena, Whole Wheat Gluten, Pearl Hominy, Force, and Cook's Flaked Rice. Analyses of these and other cereals will be found in another place (page 165). Oatmeal is richest in fat and protein; gluten comes next, and wheat, hominy, and rice follow in respective order. It is not too much again to mention the necessity of boiling these cereals with plenty of water. No attention should be paid to the extravagant claims made for some of the prepared foods. There is very little difference between any of them of the same class in nutritional value.

None of the so-called "ready-to-serve" breakfast foods should be given to infants until they have been boiled fifteen minutes.

Meat broths (111) may be started with the beginning of the second year, using preferably those made from mutton or chicken.

Between eighteen months and two years the administration of small amounts of meat may usually begin; scraped beef (151), rare roast beef, broiled beefsteak, roast lamb, broiled mutton chop, white meat of chicken,

and fresh fish, boiled or broiled, may all be employed. Meat must be given rather sparingly at the beginning and always finely minced (108), the amount depending upon the outdoor life and exercise the child may be getting. At about the same period the following vegetables may be allowed — thoroughly baked potatoes, spinach passed through a colander, string beans, peas, asparagus tips, boiled onions, and celery stewed in milk. All vegetables must be very thoroughly cooked to a pulpy consistency, in order to soften and disintegrate the cellulose (Fig. 35) and thus render them more digestible.

SAMPLE DIET FOR CHILD OF ONE AND ONE-HALF TO TWO YEARS.

7 to 7:30 A.M.	Glass of milk; cereal; a thin slice of stale bread with butter or zwieback.
11 A.M.	Glass of milk or cup of meat broth.
2 to 3 P.M.	Meats or fish—any mentioned in previous paragraph. Potatoes thoroughly baked or mashed—at first once or twice a week. Any succulent pulpy vegetable, slice of bread and butter, and one of the milk puddings.
6 to 7 P.M.	Stale bread and milk, or cereal and milk, or slice of bread and glass of milk; stewed fruit.

Tea or coffee should never be given.

Such a dietary can be maintained from the age of two to three or four years. It is naturally only suggestive and will need modifications in individual cases, both as to the periods of time and articles of diet. At the beginning, most little children will require one night feeding, and then a bottle of plain or modified milk (139) can be given at 10 or 11 P.M.

Much judgment is often required in starting the young child on a diet after the bottle has been partly or completely discarded. There is no objection to giving

milk in a bottle once or twice daily until the child is three or four years old, if it prefers this way of taking it. A bottle holding ten or twelve ounces may be used, and the nipple will at least insure its being taken slowly. Some young children will take milk in this manner while utterly refusing it when offered in a cup. By using tact in the method of giving food and employing some variety in the dietary, the baby can usually be nourished successfully. New articles must, however, be started slowly and gradually; the danger is in giving too much, both in quantity and variety, in the period between babyhood and early childhood.

PART IV.

CHAPTER XXVIII

GROWTH AND DEVELOPMENT OF INFANTS.

173. THE best gauge of good feeding and nutrition will be a proper rate of growth and development. While absolute rules cannot be given for every case, there is a normal ratio that, within certain limits, should be attained by the average infant. The exact ratio for each individual is governed by hereditary influences determining the general framework of the body at birth, as well as by the kind of food available after birth. Some infants are born with very small bones, perhaps in this respect resembling one or both parents. The birth weight of such an infant, as well as that attained later, will be less than that of a baby having a large bony framework. Different races, as well as families, show considerable variation in this respect, within the limits of health. Needless alarm is sometimes excited if the physician or mother simply considers averages that are taken from a different class or community that do not apply particularly to the baby under consideration. In every case, however, the extremely rapid growth of the infant after birth makes a careful observation of all the phenomena connected therewith not only interesting but important.

174. Of all the factors to be thus considered, weight is the most important. It is practically the most valuable, as showing whether the food has the proper nutritive in-

gredients and whether digestion and assimilation are well performing their functions. From birth on, the weight of the body must be taken and recorded at regular intervals, preferably once a week (128).

If food is being changed to try and correct a stationary or losing weight, the scales may be used every two or three days, but it must always be remembered that babies are apt to gain irregularly at short intervals. One day the infant may show a gain of an ounce and the next day

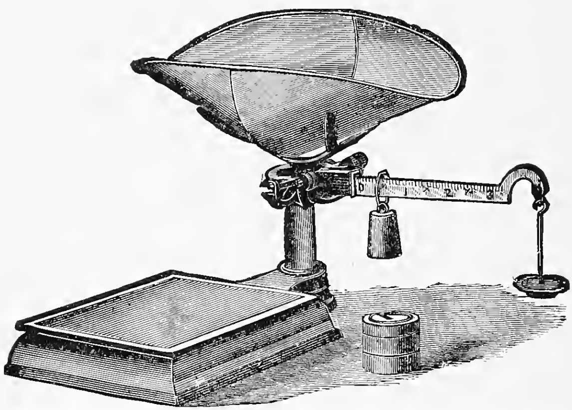


FIG. 86.— Grocer's Scales for Weighing Infants and Children.

a quarter of that amount, while doing perfectly well. Again, the weight may remain stationary for a day or so, and then jump up two ounces in twenty-four hours. The same person should do the weighing on the same scales, to insure uniformity. A grocer's scales, weighing fractions of an ounce, or those specially constructed for infants, may be used.

The following chart, devised by Carr, is convenient to record the weighings. After weighing, put a dot where the line from the infant's weight crosses the line from its

age in weeks. By connecting the dots, the weight line is the result.

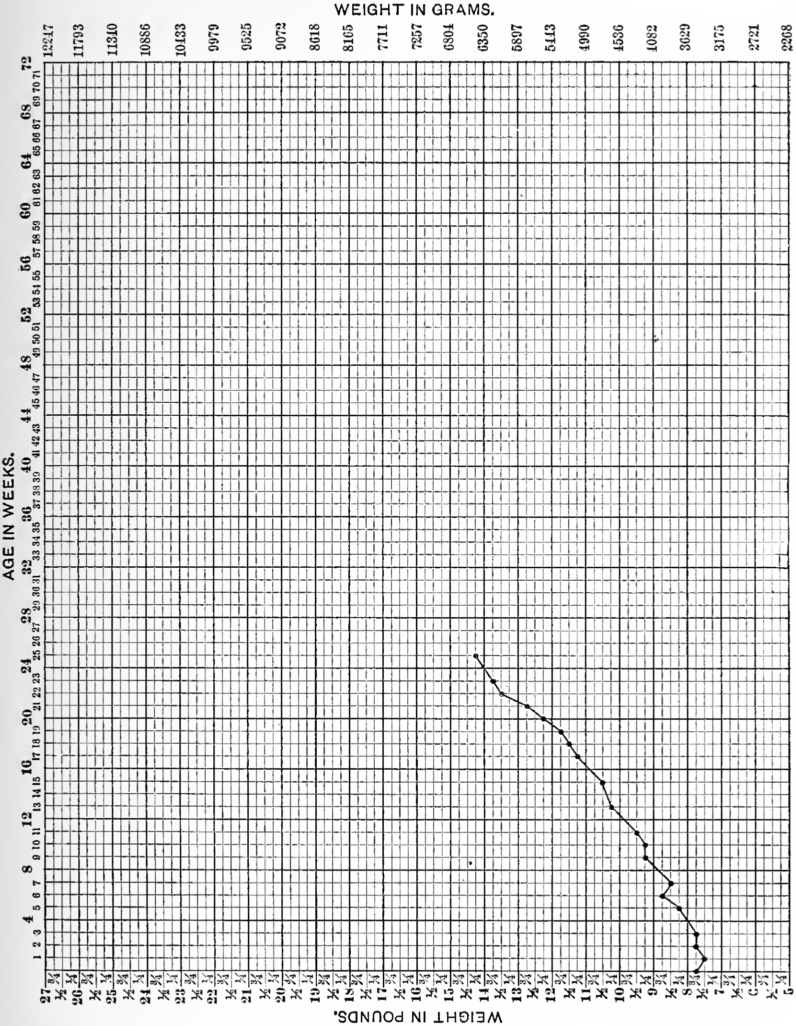


FIG. 87.—Weight Chart.

The infant should, of course, always be weighed in the same clothing, that can then be easily deducted from the total.

At birth the male infant usually weighs a little more than the female. In a series measured for the author, the males weighed from six to eight pounds, and the females from five and a half to seven pounds. During the first two months, it is considered by Rotch that the daily average gain should not fall below 20 gm. (two-thirds of an ounce). He gives the following table indicating a healthy increase in weight:

Age.	Weight.		Average Gain Per Day.	
	Grams.	Pounds.	Grams.	Ounces.
At birth	3,000–4,000	6.6–8.8		
From birth to five months	....	....	20–30	⅔–1
From five months to twelve months	....	....	10–20	⅓–⅔

The infant should double its birth weight at five or six months, and treble it at fifteen or sixteen months.

175. The length of the new-born baby is slightly greater in the male than in the female. In a number measured for the author, the males averaged 50 cm. (19.6 inches), and the females 48.6 cm. (19.1 inches).

Growth in length is extremely rapid during infancy, especially in the earlier months. It is most rapid during the first month, a little less so during the second, the rate of rapidity decreasing with each month. The following figures referring to growth in length are taken from Rotch:

The average increase for the first month is about 4.5 cm. (1¾ inches); for the second month about 3.0 cm. (1½ inches); for the third to the fifteenth month about 1 to 1.5 cm. (½ to ¾ inch); for the first year about 20 cm. (8 inches); for the second year about 9 cm. (3½

inches); for the third year about 7.4 cm. (3 inches); for the fourth and fifth years about 6.4 cm. (2⅝ inches); for the fifth to the fourteenth year about 6 cm. (2⅜ inches).

176. One of the best indices of proper nutrition is an easy and timely cutting of the first teeth. This process starts early in intra-uterine life and should be completed at the end of infancy. At birth, although nothing but smooth gums are to be seen, the alveolar processes enclose the twenty temporary or milk teeth in embryo. When beginning to come through the gums, they usually appear in groups. The first to be cut are apt to be one or

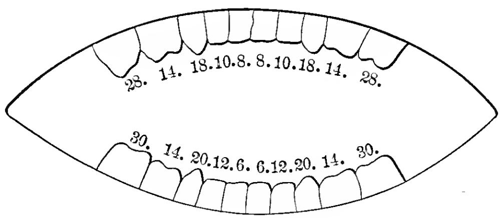


FIG. 88.—Diagram Showing Average Months for Cutting Teeth.

both of the middle lower incisors, at the sixth or seventh month. The rest are gradually evolved, usually in the following order: upper central incisors, upper lateral incisors, four anterior molars, four canines, and finally the four posterior molars. The first dentition should be completed by the end of infancy at the age of two and a half years.

There is always some variation, within the limits of health, as to the exact time of the evolution of the teeth. It may be said, however, that much delay in teething is an evidence of faulty nutrition or constitutional disease, such as rickets. Such delay must hence call for a care-

ful investigation of the food, both as to proper ingredients and adaptability for the infant's digestion.

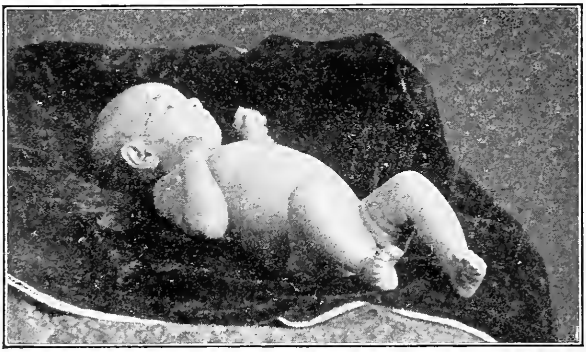


Fig. 89.—One Day Old.

177. A few pictures of normally developing infants will be shown, as affording a guide to the eye in recognizing what may be expected at various ages. Care has been

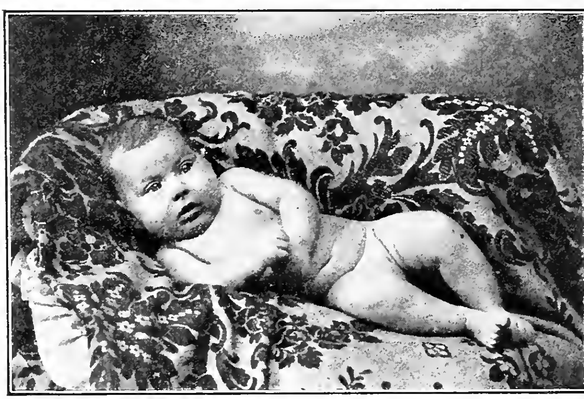


Fig. 90.—Three Months.

taken to get these pictures in natural positions and postures. Just after birth, the trunk, arms, legs, and head

have peculiar conformations. The body is of an elliptical shape, with the widest part at about the centre over the

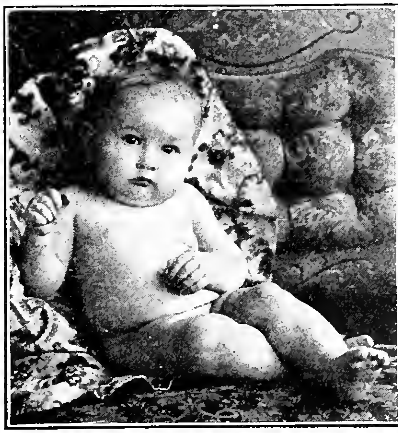


FIG. 91.—Six Months.

liver, in the region of the lower ribs. The two ends of the ellipse, represented by the thorax and pelvis, are small

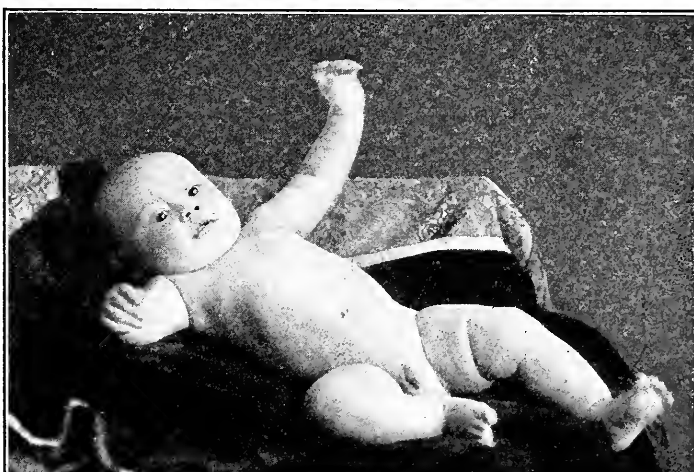


FIG. 92.—Six Months.

and not well developed. The arms are stronger and better developed than the legs. During intra-uterine life the

baby is placed in a sort of squatting position, with the legs drawn up and curled inward. This explains why the

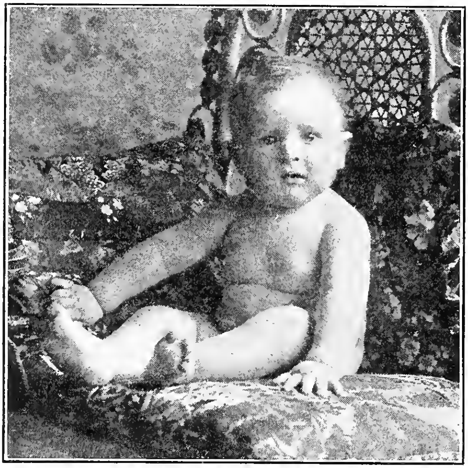


Fig. 93.—Twelve Months.

young infant's legs are not straight, but have a decided bowing in of the tibia and fibula. The soles of the feet

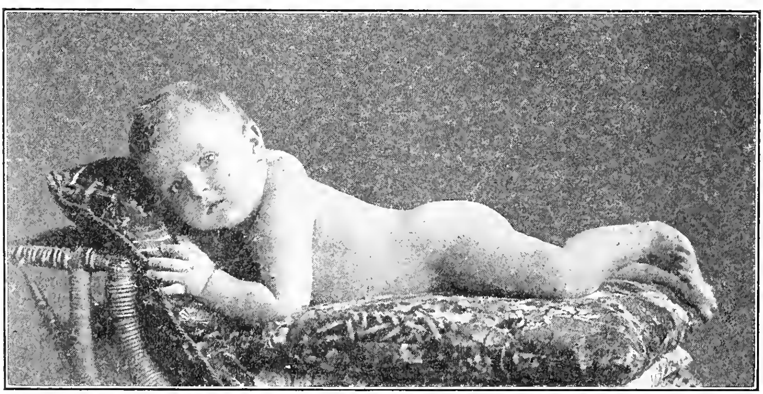


Fig. 94.—Twelve Months.

also tend to face inward. The head is larger than the chest at this time, with a very short neck, and the baby

assumes a position of general flexion. The peculiarities of early infantile shape and position are well shown in the illustrations.

For a time after birth the greatest relative strength is shown in the hands and arms, as one can easily verify by allowing the infant to grasp a finger and then trying to pull it away. At about three months the muscles of the

FIG. 95.—Fourteen Months.

neck have developed sufficiently to allow the infant to try and hold up its head in an uncertain way. At the seventh or eighth month the muscles of the back have become strengthened so that the baby can sit up, and shortly after this the infant may be allowed to creep. There should be given free play for the muscles of the arms and legs from the first, as muscular and bony development is thus

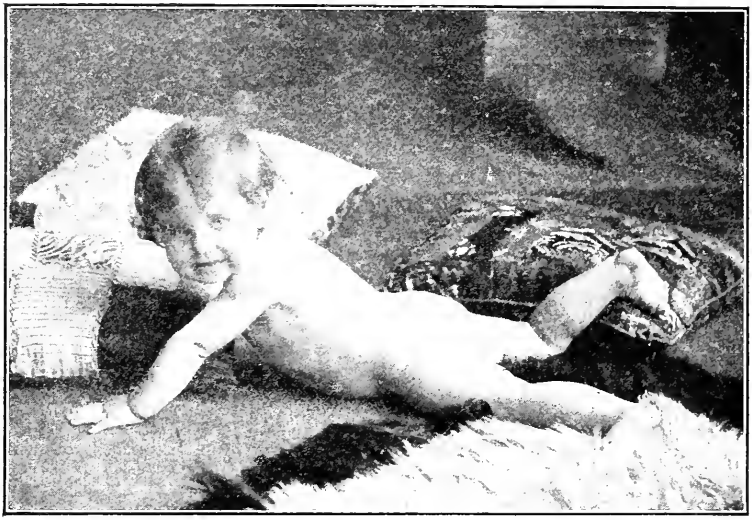


FIG. 96.—Fourteen Months.

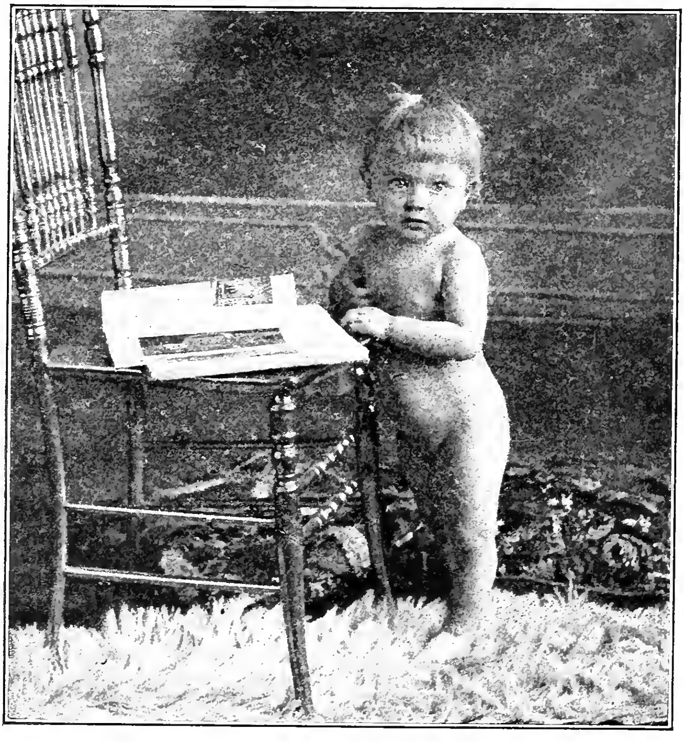


FIG. 97.—Eighteen Months.

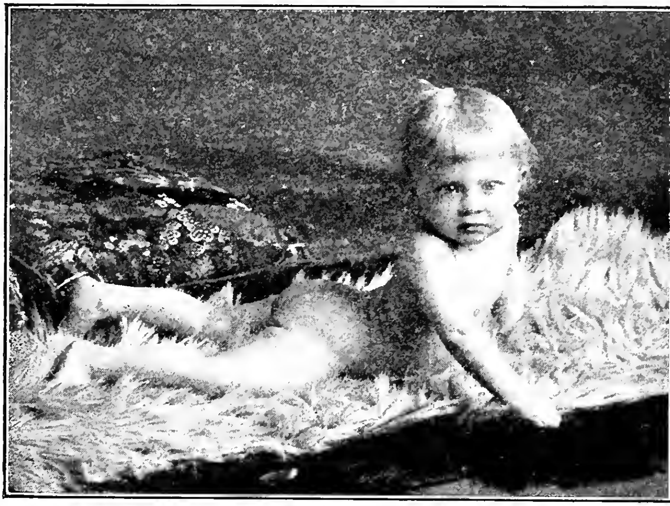


FIG. 98.—Eighteen Months.

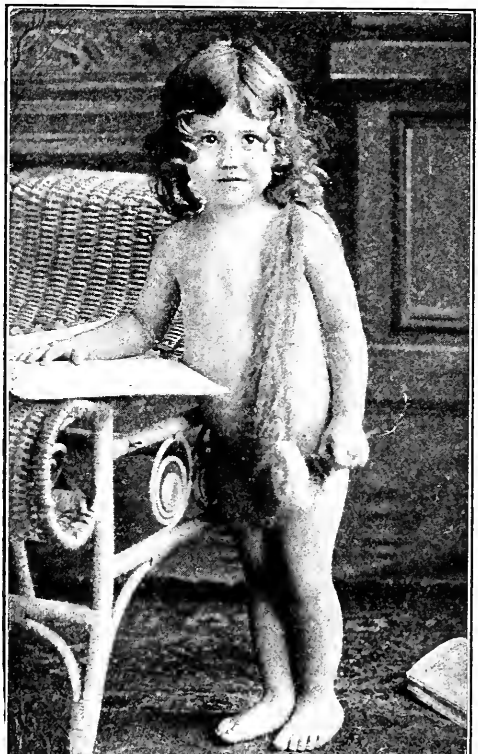


FIG. 99—Two Years.

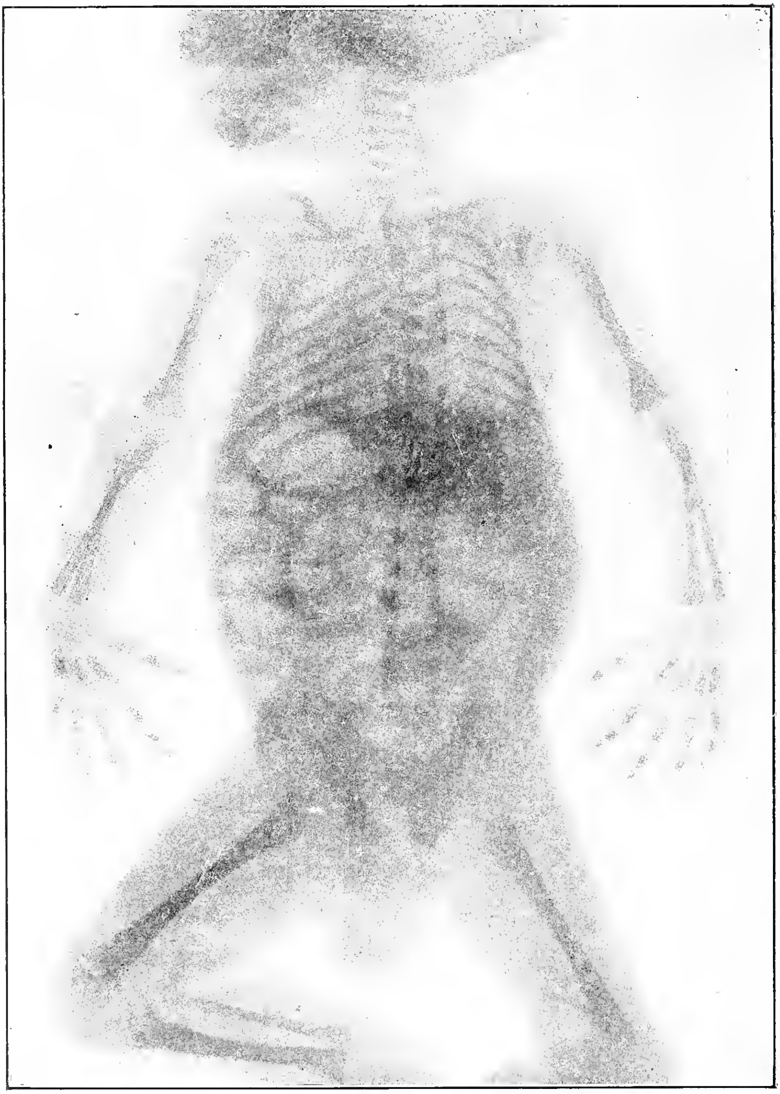


Fig. 100.—Röntgen Picture of an Infant at Nine Weeks.

encouraged. The bones of the legs thus grow and straighten out, but this will be interfered with if the baby is made to sustain the weight of the body too soon.

The average baby should not be encouraged to stand before the twelfth month; efforts to walk may be begun from then on to the fifteenth and sixteenth month. When walking has been established the legs should be straight. The chest develops rapidly, with enlargement of the pectoral and shoulder muscles, and its circumference usually equals that of the head by the end of the first year. The Röntgen picture taken for the author by Dr. W. J. Morton shows the undeveloped condition of the bones of a young infant, and the importance of giving proper nutriment to build up these and other tissues.

CHAPTER XXIX

Methods and Results of Measuring Normal Infants.

178. In order to have additional and new data relative to the growth of healthy infants, a series of careful measurements were made for the author by Dr. A. Hrdlicka, the anthropologist, assisted by Dr. Pisek. Two hundred infants were thus examined, and the tables and deductions given below are obtained solely from this work. By having one man alone, and he an expert, make all the measurements with instruments of precision, it is believed that reliable statistics have been obtained. At the same time only a few measurements that would throw light upon the general development of the infant were taken, so that any careful person can make similar measurements for comparative purposes. Healthy children from the nurseries of the New York Infant Asylum, the New York Foundling Asylum, and the Mount Vernon Infant Asylum were used, and the author extends thanks to these institutions for the courtesies extended. The ages of the infants varied from the new-born of a few hours to those of two years. There were ninety-six males and one hundred and four females. Well-developed children only were selected, the majority being on the breast and the remainder bottle-fed but in every instance doing well on its feeding. Any child who had been in hospital or showed signs of marasmus, rickets, or other constitu-

tional disease was rejected, as the purpose was to obtain the measurements of the average healthy child at various

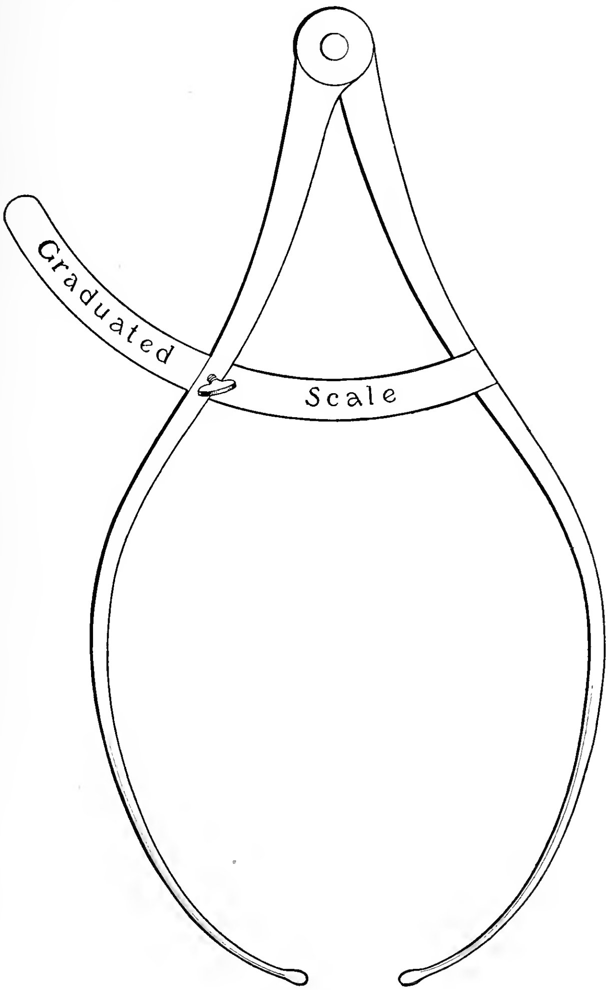


FIG. 101.—French Calipers.

ages. The instruments used for this work were a French non-stretchable tape for the circumferences, a pair of French calipers for the diameters, and a measuring board

to determine the length. The board was designed to give true results and obviate the inaccuracies obtained in the usual forms of apparatus employed. In the ordinary forms the pelvis can be tilted, as only one foot is provided for by the construction.

The measuring board here used consists simply of a plain board about forty inches long by eleven inches wide, with a firm upright headpiece attached at one end and a sliding footboard at the other end.

On the board two engine-ruled metric scales are placed parallel to each other. Care must be taken to

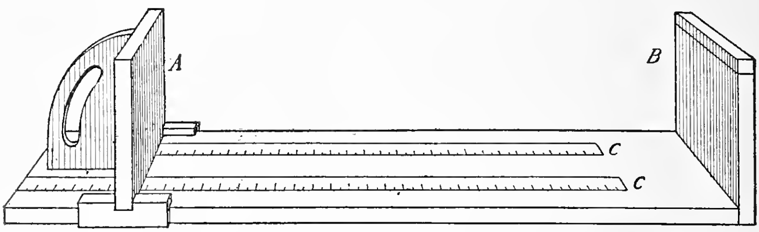


FIG. 102.—Measuring Board. *A*, Sliding foot-board; *B*, headpiece; *C*, metre scales.

have the child's head well up against the headpiece and held there by an assistant, while the measurer presses down both knees, pushing the footboard close to the plantar surfaces of the feet. The infant is then removed and a reading made on the scale.

The following measurements were taken:

Head { Circumference,
Antero-posterior diameter,
Lateral maximum diameter.

Chest—circumference.

Length of body.

Weight of body.

The relation of the weight to the length, the relation of the circumference of the head to the length, and the relation of circumference of the chest to the length were then calculated. Tables were next prepared dividing the results according to ages in weeks. The *résumé* given below has been reduced to ages in months for the purpose of brevity and simplicity. The largest and smallest measurement of each group is indicated in the metric system, and in inches, and pounds and ounces.

If we study the table, we find that the males weigh more than the females throughout the period of twenty-four months. In length the males also exceed the females, but the difference is slight up to the twelfth month, when the males show a greater divergence. This is well shown in the relation of weight to length in the last column. The circumference of the head is greater than the circumference of the chest at birth, and remains so up to the middle of the first year, when they begin to approximate in size; at the end of the first year the chest grows larger than the head. The females, it will be noticed, begin to show greater circumference of chest to head at the tenth month, which remains so throughout. The columns giving the relationship which exists between the circumference of the head and the length of body, and that of the head to the chest, will be an aid in recognizing abnormal cases, such as rickets or hydrocephalus.

The relations spoken of above are obtained from the measurements as follows:

1. Weight to the length.

Multiply grams of weight by 100 and divide by centi-

metres of length. Example: Weight 2,778 gm. × 100 ÷ 50 cm. length = 55.6, relation of weight to length.

2. Relation of circumference of head to length of body.

TABLE OF MEASUREMENTS (MALES).

Males. Age	Weight			Length		Circ. of head		Circ. of chest		Ratios of measurements			
	Grams	Lbs.	Oz.	Centimeter	In.	Centimeter	In.	Centimeter	In.	Circ. of head to chest	Circ. of head to length	Circ. of chest to length	Weight to length
	2778	6	15	50.	19.6	35.1	13.8	32.	12.6	91.1	65.8	63.	54.9
1 day-1 month	to 3912	8	9	55.3	21 8	38.3	15.1	36.7	14.4	95.8	72.1	71.6	76.7
	3374	7	6	52.5	20.7	36.6	14.4	35.	13.3	95.6	66.1	63.8	62.2
1 - 2 months	to 5216	11	7	59.6	23.5	39.5	15.5	38.	15.	96.3	71.6	68.3	87.6
	3459	7	9	55.9	22.	38.9	15.3	34.9	13.7	89.7	67.1	61.7	59.8
2 - 3 "	to 5528	12	2	60.8	23.9	41.2	16.2	41.2	16.2	100.	70.8	69.5	92.4
	5018	11	0	59.1	23.3	40.2	15.8	37.5	14.8	93.3	64.9	60.4	82.1
3 - 4 "	to 6804	14	15	63.1	24.8	44.	17.3	42.	16.5	95.5	70.7	69.	107.8
	6152	13	8	66.2	25.	41.3	16.3	41.1	16.3	99.5	62.3	62.1	92.9
4 - 5 "	to 7201	15	13	66.3	26.1	42 2	16.6	43.2	17.	102.4	63.7	65.2	108.6
	4990	11	9	59.	23.	40.5	16.	39.9	15.7	98.5	64.1	63.2	83.7
5 - 6 "	to 7796	17	2	68.5	27.	43.9	17.3	43.3	17.	98.9	69.	67 9	113.8
	5698	12	8	64.8	25.5	43.2	17.	41.2	16.2	95.4	65.3	62.6	87.9
6 - 7 "	to 7995	18	0	68.7	27.	45.3	17.8	45.2	17.8	99.8	67.5	68.2	119.1
	4536	9	15	59.1	23.3	40.	15.7	38.	15.	95.	62.7	63.4	76.8
7 - 8 "	to 7924	17	6	70.8	27.9	44.4	17.5	44.9	17.7	102.	69.1	64.3	111.9
	6804	14	15	66.1	26.0	44.7	17.6	40.8	16.1	91.3	63.3	59.5	101.5
8 - 9 "	to 8661	19	0	70.8	27.9	47.3	18.6	47.1	18.5	99.6	69.2	69.	122.3
	6662	15	1	64.8	25.5	42.9	16.9	42.3	16.7	98.6	65.1	64.8	102.5
9 - 10 "	to 8732	19	2	71.1	28.	46.3	18.2	46.1	18.2	99.6	68.3	66.	122.8
	6776	14	14	64.7	25.5	44.8	17.6	39.2	15.4	87.5	63.6	56.3	104.7
10 - 11 "	to 8565	18	12	79.	31.	45.5	17.9	45.3	17.8	99.6	69.5	68.	119.9
	6634	14	9	66.1	26.	44.7	17.6	43.4	17.1	97.1	64.9	64.5	99.4
11 - 12 "	to 8392	18	3	69.8	27.5	45.3	17.8	45.1	17.8	99.5	67.3	68.2	120.2
	7938	17	8	69.4	27.3	45.6	18.	42.1	16.5	92.3	63.8	60.7	114.4
12 - 13 "	to 9157	20	1	71.5	28.2	47.	18.5	48.3	19.	102.7	66.6	67.3	128 1
	7258	15	15	69.6	27.4	46.	18.1	42.1	16.5	91.5	63.4	60.5	104.3
13 - 14 "	to 8874	19	7	76.	29.9	48.3	19.	47.7	18.8	98.8	67.7	64.3	121.1
20 - 21 "	10093	22	2	75.7	29.8	48.1	18 9	50.1	19.7	104.2	63.5	66.2	133.3
	8108	18	5	72.2	28.4	45.	17.7	43.8	17.2	97.3	57.4	60.6	112.3
22 - 23 "	to 11113	24	6	83.4	32.8	47.9	18.9	51.7	20.4	107.9	62.3	61.9	133.3
	10886	23	14	76.4	30.1	47.6	18.7	50.7	19.9	106.5	59.7	61.9	132.8
23 - 24 "	to 11113	24	6	82.	32.3	49.	19.3	50.8	20.	103.7	62.3	66.4	145.5
2-3 years	10830	23	12	79.8	31.4	49.	19.3	49.9	19 6	101.8	61.4	62.5	135.7

Multiply circumference of head by 100 and divide by length of body. Example: 35.1 × 100 ÷ 50 = 70.2.

3. Relation of circumference of chest to length of body.

Multiply circumference of chest by 100 and divide by length of body. Example: $32 \times 100 \div 50 = 64.0$.

4. Relation of circumference of head to circumference of chest.

Table of Measurements (Females).

Females Age	Weight			Length		Circ. of head		Circ. of chest		Ratios of measurements			
	Grams.	Lbs.	Oz.	Centi-meter.	In.	Centi-meter.	In.	Centi-meter.	In.	Circ. of head to chest.	Circ. of head to length.	Circ. of chest to length.	Weight to length.
	2580	5	10	48.6	19 1	33.4	13.1	30.	11.8	89.8	66.1	61.7	53.1
1 day-1 month	to 3601	7	14	52.8	20.8	37.1	14.6	35.9	14.1	96.8	72.2	69.8	71.7
	3373	7	6	52.	20.5	35.3	13.9	32.8	12.9	95.7	62.6	61.5	64.9
1 - 2 months	to 4678	10	4	59.3	23.3	39.	15.4	39.	15.4	100.	73.2	66.8	78.9
	3799	8	5	54.6	21.5	37.3	14.8	34.8	13.7	93.3	65.8	59.7	67.
2 - 3 "	to 6010	13	3	62.	24.4	41.1	16.2	39.8	15.7	96.8	70.1	68.9	101.
	4281	9	6	56.3	22.2	39.	15.4	36.2	14.3	92.8	64.2	61.8	75.7
3 - 4 "	to 5698	12	8	61.9	24.4	42.1	16.6	44.	17.3	104.5	72.4	71.7	97.7
	4494	9	14	59.9	23.6	40.2	15.8	37.1	14.6	92.3	65.7	60.5	75.
4 - 5 "	to 5585	12	5	62.3	24.5	41.3	16.3	41.7	16.4	100.9	67.	66.9	89.6
	5500	12	2	61.9	24.4	41.7	16.4	38.6	15.2	92.5	65.3	59.	88.8
5 - 6 "	to 6519	14	6	66.1	26.	44.6	17.6	43.2	17.	96.8	67.9	66.1	99.7
	6634	14	9	63.9	25.2	43.1	17.	39.8	15.7	92.3	65.6	62.3	103.8
6 - 7 "	to 7768	17	1	66.	26.	43.8	17.2	43.1	17.	98.4	67.6	65.4	117.7
	6577	14	7	63.2	24.9	42.7	16.8	42.1	16.6	98.6	63.	66.6	104.1
7 - 8 "	to 8760	19	3	69.9	27.5	44.	17.3	46.8	18.4	106.4	68.8	70.7	125.3
	7030	15	7	65.8	25.9	42.1	16.6	41.2	16.2	97.8	63.8	61.1	104.6
8 - 9 "	to 7853	17	3	68.8	27.1	46.2	18.2	43.7	17.2	94.6	67.2	66.2	115.5
	5557	12	3	62.9	24.8	42.4	16.7	39.3	15.5	92.7	66.5	61.	88.3
9 - 10 "	to 6804	14	15	64.4	25.4	42.8	16.9	40.8	16.1	95.3	67.2	61.8	105.6
	5188	11	6	64.4	25.4	43.6	17.2	42.5	16 7	97.4	64.8	63.4	80.6
10 - 11 "	to 9044	19	13	69.8	27.5	45.9	18.1	48.	19.	104.6	70.8	69.1	129.5
	6932	15	3	63.7	25.1	43.7	17.2	42.8	16.9	97.9	63.2	62.1	107.
11 - 12 "	to 9299	20	6	71.3	28.1	46.3	18.2	48.3	19.	104.3	69.2	72.4	134.8
	6152	13	8	62.5	25.6	41.1	16.2	43.1	17.	104.8	61.7	67.7	98.4
12 - 13 "	to 8590	18	13	71.1	28.	44.	17.3	48.1	18.9	109.3	65.8	68.9	120.8
	7655	16	14	70.5	27.7	45.3	17.8	45.1	17.8	99.5	63.	63.7	108.6
13 - 14 "	to 9526	20	14	72.6	28.6	48.1	18.9	49.4	19.	102.7	66.9	70.	131.2
	7513	16	8	69.1	27.2	44.7	17.6	45.2	17.8	101.1	61.7	62.4	103.8
16 - 17 "	to 8080	17	11	72.4	28.5	45.1	17.8	47.2	18.6	104.6	65.3	68.3	116.9
17 - 18 "	7626	16	12	71.4	28.1	44.3	17.4	43.9	17.3	99.1	62.	61.1	106.8
19 - 20 "	8335	18	3	73.9	29.1	46.3	18.2	46.6	18.3	100.7	62.7	63.1	112.8
23 - 24 "	8789	19	4	77.5	30.5	45.6	18.	47.1	18.5	103.3	58.8	60.8	113.4

Multiply circumference of head by 100 and divide by circumference of chest. Example: $32 \times 100 \div 35.1 = 91.1$.

While infants at birth may vary widely in size, each

individual should develop in proper proportion, the various parts of the body having a symmetrical relationship to one another. These tables will thus be found useful in estimating a divergence from the normal average in any given child. Thus, for example, we have a male in-

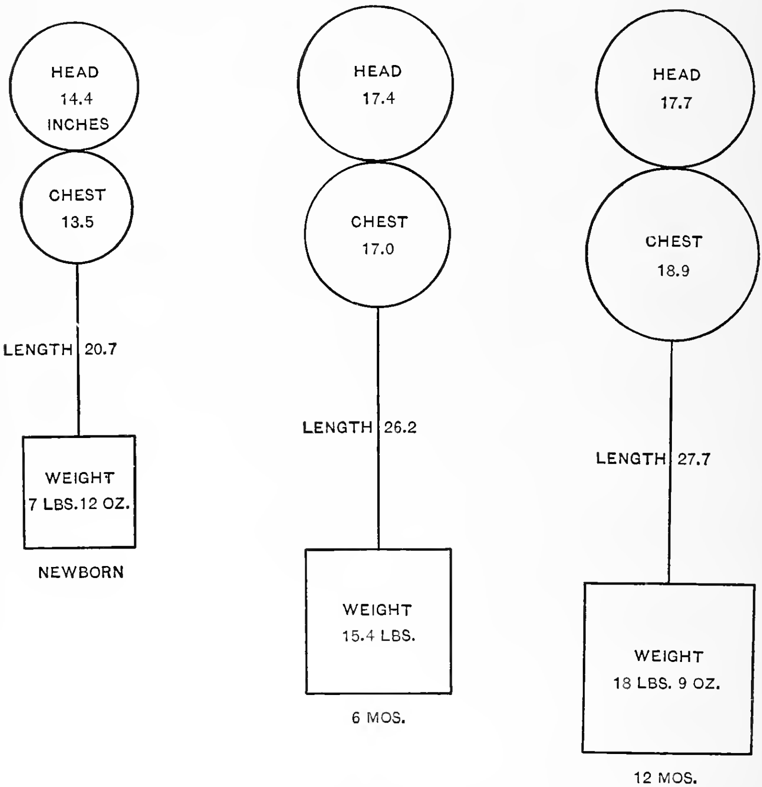


FIG. 103.—Diagrams of Relative Measurements Constructed from Table.

fant of five and a half months that comes for examination and to have its feedings regulated. It is determined that this infant should not weigh less than 4,990 gm., the length should be between 59.0 and 68.5 cm., the circumference of the head should average about 42.0 cm., the

chest slightly below this figure, and the proportion of the length to the weight should not fall below 98.8.

The diagrams (Figs. 91 and 92) done in scale will show to the eye the averages of the table at various ages.

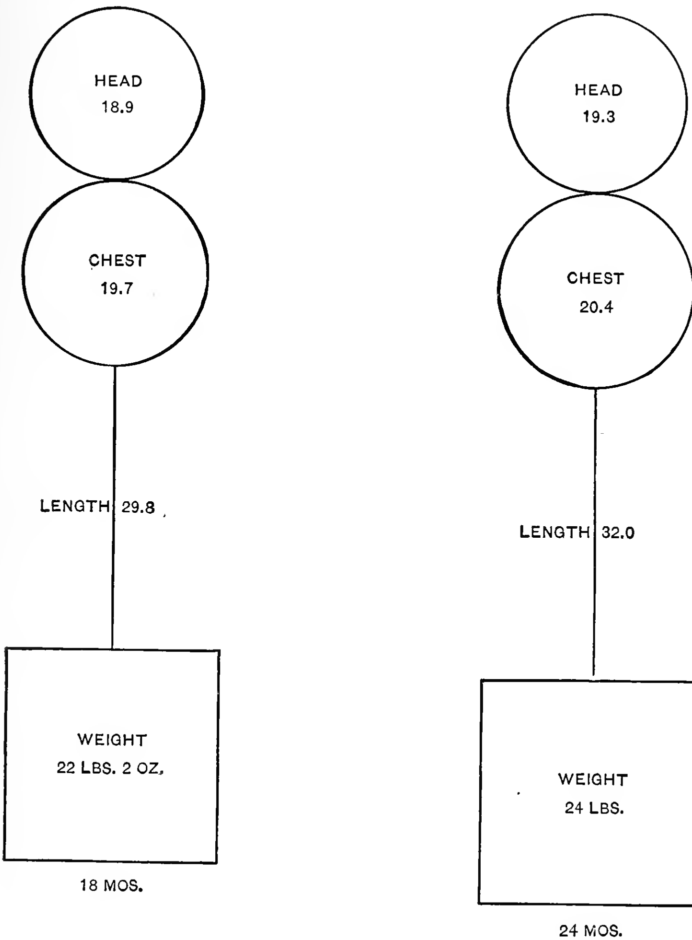


FIG. 104.—Diagrams of Realative Measurements Constructed from Table.

CHAPTER XXX.

Growth of Head.

179. In the human being the brain assumes overmastering importance in the scheme of evolution, hence its proper growth and development assumes relatively more importance than that of other parts of the body. The extremely rapid evolution of the brain during infancy, and the fact that the future efficiency and well-being of the individual depend so largely upon its normal and healthy growth, render a study of the infantile head of great interest. As the skull is fairly representative of the brain during the years of its first development, measurements taken during infancy are more instructive as to brain size and development than those taken in later years. The skull changes considerably in its proportions during the first three years of life, and then more slowly up to the end of the seventh year, when it has very nearly attained its full size. Ninety-eight cases, from birth up to two years, were carefully measured by the author, and the results are incorporated in the following table.

Some of these figures are very slightly under similar measurements made by Dr. Hrdlicka in his series upon the general growth of infants. This is explained by the fact that the author made his studies upon hospital cases, where the subcutaneous tissue over the skull is apt to be somewhat atrophied. The bony configuration of the

TABLE OF HEAD MEASUREMENTS.

	Under one week. From birth, nine cases all on breast.	From one week to one month, twenty cases, eighteen on breast.	From one to three months, eighteen cases, seven on breast.	Three and four months, nine cases, three on breast.	Five and six months, nine cases, one on breast.	Seven and eight months, five cases one on breast.	Nine and ten months, eight cases, two on breast.	Eleven and twelve months, six cases.	From twelve to eighteen months (inclusive). Eight cases, two on breast.	From eighteen months to two years, six cases.
	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.
Great circumference	34.72	35.09	37.25	38.55	38.94	41.3	42.68	44.91	46.81	47.41
Approximate volume, c.c.	917.44	969.03	1,005.75	1,040.85	1,051.38	1,115.1	1,152.36	1,212.57	1,263.87	1,280.07
Naso-occipital arc........	22.33	23.05	24.86	25.83	26.05	27.9	28.81	30.41	31.00	32.83
Naso-bregmatic arc	9.22	9.80	9.55	10.05	9.83	11.6	11.12	12.41	12.68	13.16
Bregmato-lambdoid arc ..	8.94	8.90	9.83	10.11	10.16	9.0	11.06	11.33	10.68	11.41
Lambdo-occipital arc.....	4.16	4.80	5.48	5.66	6.05	7.3	6.62	6.66	7.62	8.25
Binauricular arc (through bregma)	22.00	22.95	23.55	24.38	23.83	26.6	26.68	28.33	28.31	29.33
Binauricular arc (through lambda)	21.61	23.05	23.75	25.05	25.22	26.9	26.68	27.66	29.25	29.91
Diameters ant. font.—										
Antero-posterior.....	4.00	4.45	4.05	3.88	3.77	3.6	3.00	3.00	1.87	Closed.
Lateral	3.00	3.70	3.16	3.33	3.38	3.2	2.75	2.41	1.68	Closed.
Cephalic index...........	$\frac{9.11}{11.44}=79.63$	$\frac{9.25}{12.30}=75.20$	$\frac{9.94}{12.72}=78.14$	$\frac{10.11}{13.22}=76.47$	$\frac{10.44}{13.44}=77.67$	$\frac{11.2}{13.8}=81.15$	$\frac{11.37}{14.62}=77.77$	$\frac{12.5}{15.0}=83.33$	$\frac{12.00}{15.62}=76.82$	$\frac{12.16}{16.33}=74.46$
Facial length............	4.94	5.39	5.75	5.72	5.94	6.3	6.05	6.75	6.68	7.05

skull, produced by the growing brain, would, however, not be affected by this circumstance. No distinction was made between the sexes. The circumference was taken by passing the tape horizontally around the head, passing over the glabella and a point just above the external occipital protuberance. When this is procured the following data will give a very rough approximation of the volume: x : circumference : : 1350 : 50. Thus, if the circumference is 42 cm., the approximate volume will be

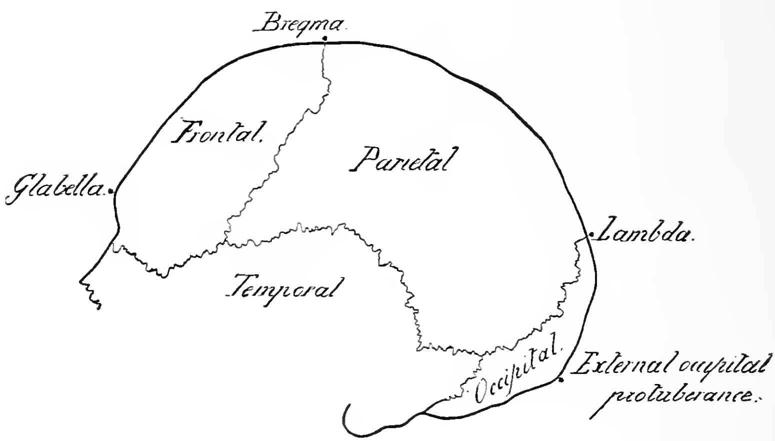


FIG. 105.—Outline of the Skull.

1134 c.c. The naso-occipital arc was measured from the glabella to the external occipital protuberance. Before removing the tape, the three arcs composing the naso-occipital were read off — namely, the naso-bregmatic, the bregmato-lambdoid, and the lambdo-occipital arcs. These points are shown in the following outline of a skull, and are easily recognized in the infant.

The bregma and lambda were previously marked with an aniline pencil, so that the readings on the tape at

these points could be readily made. Where the anterior fontanel was open, a line in continuation of the frontal sutures was marked. The binauricular arcs were measured, in both cases, from the anterior rim of the meatus, and passing the tape respectively over the bregma and lambda. When the anterior fontanel was open, the antero-posterior and lateral diameters were taken. The cephalic, or length-breadth index, was measured by calipers, which were applied at the greatest biparietal and antero-posterior diameters. The formula for obtaining this index is as follows: Length : Breadth : : 100 : x. All cephalic indices falling below 78 are classed as dolichocephalic; from 78 to 80, mesocephalic; and above 80, brachycephalic. The facial length was measured from the root of the nose to the extremity of the chin, and, in the absence of the teeth, falls relatively considerably be low the adult. A configuration of the skull in each case was taken by carefully applying a strip of sheet-lead horizontally around it, just above the ear, the free ends always being on the right side for the purpose of uniformity. The tracing was then put upon a chart by running the point of a sharp pencil just inside the lead. It is well to mark the centre of the lead in front, so as to be able approximately to draw a median line through the configuration and thus detect asymmetry. It is not contended that this is an absolutely accurate method of obtaining a configuration of the skull, as the metal is so yielding that there is a possibility of its springing somewhat in transferring it from the skull to the chart. With care, however, it is fairly accurate, and will exhibit the general pushing out of the soft skull by the growth of the brain,

and any form of asymmetry that is at all marked. The following configurations, taken from the list, are fairly typical of the usual shaping of the skull, in a horizontal plane, at various ages during its most rapid growth.

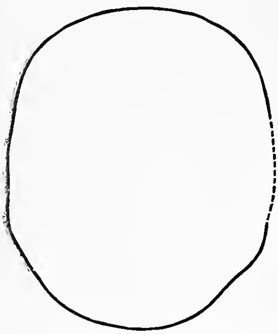


FIG. 106.—Fetal Skull, Between Three and Four Months.

180. The fetal skull is very small, and oval at an early stage, as both the sensori-motor and intellectual centres have not yet begun to grow. The former begins to develop later in intra-uterine life, and the latter the last of all. This is beautifully shown in the configurations of the two fetal skulls. The first shows an oval, undeveloped brain, while the second exhibits the forcing out of the parietal bosses by the rapid evolution of the sensori-motor area of the brain, while the front of the skull appears stationary, from the size of the configuration. After birth and with increase in the age of the infants, there is noted a gradual and steady enlargement of the great circumference of the skull, and, from this, of its estimated

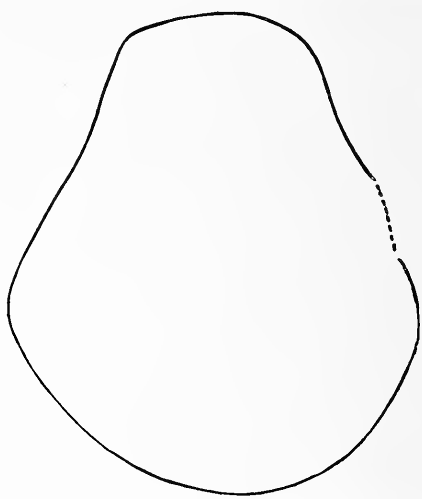


FIG. 107.—Fetal Skull, Seven Months, Showing the Forcing Out of the Parietal Bosses by the Development of the Sensori-motor Area of Brain.

volume. The naso-occipital arc likewise increases at about the same general rate as the great circumference. In comparing the naso-occipital arc with the great circumference, there is an increasing difference

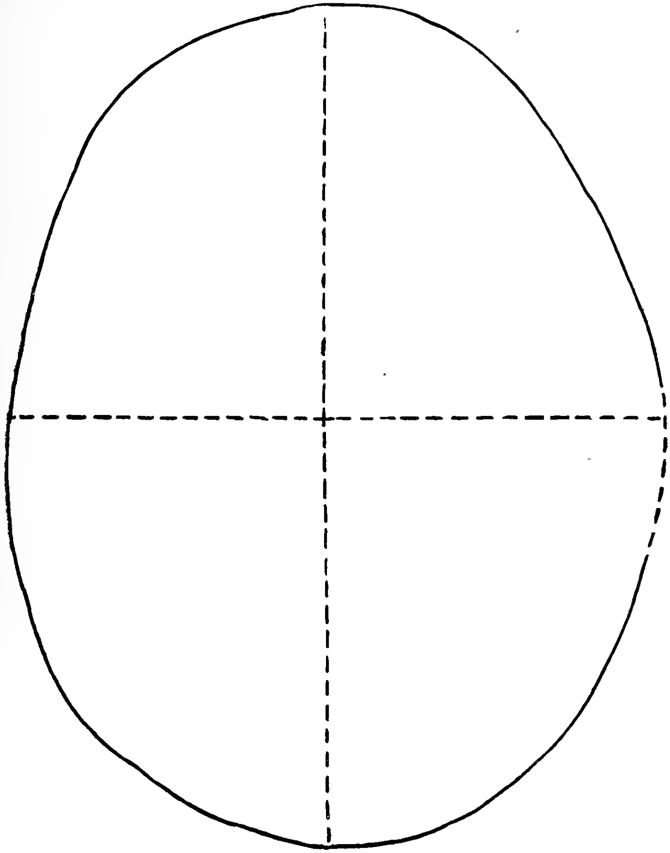


FIG. 108.—Horizontal Configuration of New Born Baby (Female), Small, but Symmetrically Developed.

Measurements.

Great circumference, 31 cm.
Naso-occipital arc, 22 cm.
Naso-bregmatic arc, 9 cm.
Bregmato-lambdoid arc, 9 cm.
Lambdo-occipital arc, 4 cm.
Binauricular arc (through bregma), 22 cm.
Binauricular arc (through lambda), 24 cm.
Diameters of anterior fontanel—antero-posterior, 5.5 cm.; lateral, 5 cm.
Cephalic index, 8-10.
Facial length, 5 cm.
Circumference of chest, 26 5 cm.
Length of body, 46.5 cm
Weight of body, 5 pounds.

as the infants grow older. Thus, in the table, the difference under one week is 12.39 cm., while at two years it is 14.58 cm. The naso-bregmatic and bregmato-lambdoid arcs are very similar in the series, but after seven months the former arc becomes slightly larger from the development of the frontal lobes of the brain. While the parietal bosses cover the sensory and, to a certain extent, the motor cortical areas, the bones of the forehead will indicate by their shape the stage of development of the frontal lobes, the foundation of the intellectual portion of the brain. Although no intellectual growth can be said to take place under two years, there should be an active evolution of the front of the brain, with increase of the perceptions. The first rapid growth of the brain after birth is more in bulk than in size and complexity of the convolutions. Hence in early infancy the various cortical centres have but a slight development and function. With proper evolution, the convolutions grow and are arranged in functional groups, which groups, by their growth, alter and modify the shape of the infantile skull. If the skull is small or improperly shaped in any part, the brain in such an area is imperfectly developing. A certain amount of asymmetry, however, is found in all skulls, as in the other members of the body, and will be seen in the tracings previously shown. Older children sometimes exhibit a compensatory deformity from a too early closure of some of the sutures of the infantile skull, that does not allow the expanding brain to develop in a symmetrical manner. Such cases are not apt to exhibit abnormality of brain function. The brain has simply pushed out at the point of least resistance.

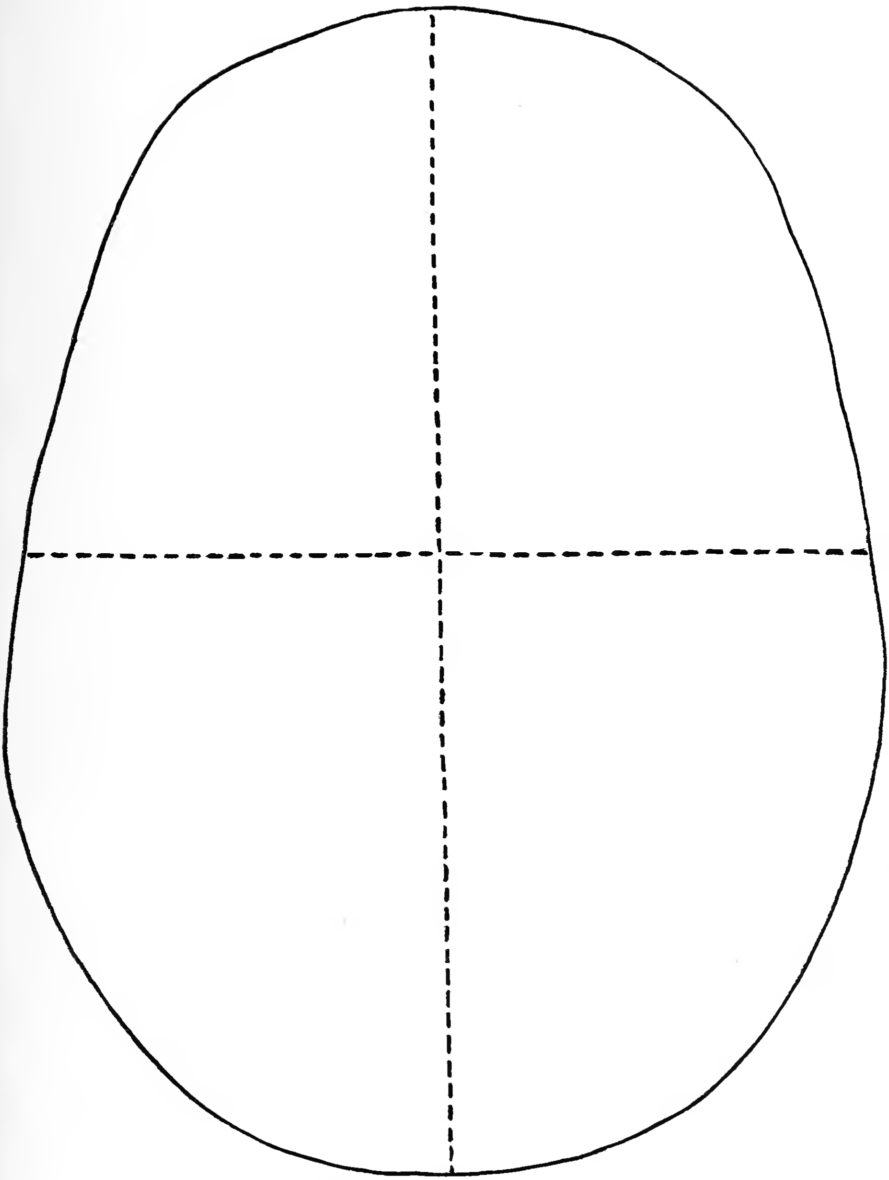


FIG. 109.—Horizontal Configuration of Baby of Ten Months (Female). Fed on breast.

Measurements.

Great circumference, 44 cm.
Naso-occipital arc, 29 cm.
Naso-bregmatic arc, 11.5 cm.
Bregmato-lambdoid arc, 12.5 cm.
Lambdo-occipital arc, 5 cm.
Binauricular arc (through bregma), 26 cm.
Binauricular arc (through lambda), 26.5 cm.

Diameters of anterior fontanel—antero-posterior, 1 cm.; lateral, 1 cm.
Cephalic index, 11-15.
Facial length, 6 cm.
Circumference of chest, 43.5 cm.
Length of body, 68 cm.
Weight of body, 14 lbs. 13 oz.

181. The fontanel is usually completely closed from the eighteenth to the twentieth month. As will be seen from the table, the closing is rather slow until the twelfth month, when it proceeds much more rapidly. In all the cases examined, the fontanel had closed by the eighteenth month. Where the fontanel remains widely open with the increased age of the infant, there will always be marked symptoms of rickets elsewhere. Thus, in the case of a male infant, aged ten months, with both diameters 5 cm., the configuration showed a markedly rickety head, and the notes gave other symptoms of the disease.

The facial length increases slowly in infants, as would be expected from the absence of teeth. In older babies, when dentition is completed, the length increases more rapidly.

The importance of good nutrition in relation to brain growth will be appreciated from the fact that, in the cases examined by the author, the skulls of breast-fed babies presented slightly larger measurements than those artificially fed, especially when the latter were not digesting and assimilating their food well.

The principle of biology, that the development of the individual reproduces, on a small scale, the development of the race, is well shown in the infant's brain. The higher centres and the centres of association are developed late in the child. These are likewise the last acquirements of the race. The lower and more fundamental animal traits are transmitted by inheritance more than the higher ones. Good nutrition and good training are both required to develop the higher functions of the brain in a satisfactory manner.

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INDEX.

APPENDIX.

STANDARDIZED GRUELS.

FROM time immemorial cereal gruels have been used as a bland diet in fevers and in gastro-intestinal affections, when milk and other more solid food was contraindicated. In more recent times, since the problem of artificial infant feeding has forced itself to the front, gruels have been used to dilute cow's milk for infants because of their effect of softening the milk curds in the stomach and rendering the milk more digestible.

The use of gruels for this purpose has been decried by some on theoretical grounds, it being claimed that it was unnatural, as human milk did not contain cereals. But it was just as apparent that human breasts did not secrete cow's milk; and that as some substitute for breast milk had to be chosen, it was justifiable to use what gave good results. No one who has had experience with the use of cereal gruels in infant feeding will deny that marked improvement often follows their use, and that they are the main reliance when milk must be temporarily discontinued. In spite of their well-known clinical value there has been a general impression that their use as a routine measure was unscientific.

It has been taught that the proper way to modify cow's milk for infants was, in addition to diluting it and adding

cream and sugar, to add a certain amount of alkali ostensibly to overcome the acidity of the cow's milk. In practice, however, enough alkali was often added to change the casein of the milk into a compound that would not form curds in the stomach, and very often more than enough to neutralize the action of the infant's gastric secretions. The addition of alkali to milk really retards the process of gastric development, and often perverts it by throwing the entire work of digestion on the intestines. The effect of gruel diluents, on the contrary, is mechanically to soften the curds and thus allow the digestive tract to perform its function naturally.

While it is well established that good clinical results often follow the addition of alkalies or antacids to cow's milk, it is going too far to lay it down as a general rule that the food of all infants should contain some alkali. When it is desired to prevent or retard the action of the gastric secretion on the milk, then an alkali is indicated; but for the majority of infants it is desirable and proper to let the stomach perform its function and increase in digestive capacity.

As the proteid of cow's milk is with difficulty digested by the infant, it must be reduced in quantity or modified in some way. When cow's milk is diluted with water sufficiently to reduce the amount of the proteid to suit the infant's digestive capacity, the quantity of proteid in the infant's food is often less than is needed to insure proper growth. It may be necessary then in modifying milk either to underfeed in tissue-building food (proteid), or interfere with gastric digestion by adding alkali, or mechanically modify the curds by the use of cereal diluents.

There can be no question as to which method is preferable; and therefore the writer has sought to establish cereal feeding on a scientific basis.

For the purpose of establishing some uniform standards the writer had made a number of different kinds of gruels and then had them assayed to determine their composition in order to show the relative proportion of tissue-building and heat and energy-producing elements. Pearl barley, prepared barley flour, wheat flour, and rolled or flaked oats, such as are sold in packages for family use, were used. The pearl barley was boiled for three hours in a saucepan and then strained, a portion remaining on the strainer. The rolled oats were cooked for one hour in a double boiler and then strained, a portion also remaining on the strainer. The barley and wheat flours were cooked for one hour in a double boiler and strained, practically all of the flour passing through the strainer into the gruel. The gruels thus made were sent to the New York Agricultural Experiment Station where they were assayed by the courtesy of the director, W. H. Jordan, and the following figures obtained:

PLAIN GRUELS.

	Total Solids.	Proteid (Nx6.25).
1 oz. avoir. pearl barley to quart (32 oz.)....	1.483 per cent.	0.140 per cent.
1 oz. avoir. prepared barley flour to quart (32 oz.)	2.288 "	0.195 "
1 oz. avoir. wheat flour to quart (32 oz.)....	2.494 "	0.331 "
1 oz. avoir. rolled oats to quart (32 oz.)....	1.931 "	0.262 "

DEXTRINIZED GRUELS.

6 oz. avoir. rolled oats to quart (32 oz.).....	10.92 "	1.47 "
6 oz. avoir. wheat flour to quart (32 oz.)....	15.12 "	1.81 "

It will be noticed that the composition of the gruels made with six ounces of cereal to the quart is almost exactly six times the composition of the gruels made with one ounce to the quart.

If an ounce of cereal is made up into a quart of gruel and none of the cereal is removed by straining, it is evident that each ounce of the gruel will contain $\frac{1}{32}$ ounce of the cereal and that the cereal has been diluted thirty-two times. From this illustration it is easy to see that if a definite weight of cereal is used in making the gruel, and none of it is removed by straining, the composition of any gruel can be readily calculated by dividing the composition of the cereal by the number of times it is diluted. This rule cannot be followed in the cases of cereals which are not completely broken up by cooking and part of which is removed by straining. However, it will be noticed in the assays of gruels made from rolled oats that practically the same proportion was removed in the gruel made with six ounces as in the gruel made with one ounce of the oats, so this amount can be allowed for.

To determine on a convenient and accurate method of obtaining different weights of the cereals, the writer had twelve different trained nurses measure them with a tablespoon made level full by sliding a knife along the edges, and also with the author's one-ounce cream dipper and the quantities weighed. Inquiry of one of the largest manufacturers of spoons in the country brought out the fact that there is no accepted standard of size for tablespoons used, and that they vary slightly in capacity, although all makers kept close to one size.

It may be safely accepted, however, that

1 level tablespoonful	of	pearl barley	weighs	½	oz. avoirdupois.
1 " "	"	barley flour	"	¼	" "
1 " "	"	wheat flour	"	¼	" "
1 " "	"	rolled oats	"	¼	" "
1 ounce dipper	"	pearl barley	"	¾	" "
1 " "	"	barley flour	"	½	" "
1 " "	"	wheat flour	"	½	" "
1 " "	"	rolled oats	"	⅓	" "

A sixteen-ounce graduate of wheat flour weighs eight ounces avoirdupois, and the same measure of rolled oats weighs five ounces.

From these observations it is possible to construct a simple table for use in making gruels of any desired strength. Of course this table will not be absolutely accurate because the composition of cereals is not always uniform; and again, as the concentration of the gruels becomes greater, the increased specific gravity will slightly disarrange the calculated percentage composition. However, this table will be as accurate as the tables used in modifying cow's milk for infant feeding. The percentage methods of feeding as emphasized by Rotch are an advance in as far as they teach us to scrutinize food values. But the danger is of pushing the principle to an extreme that is liable to discredit the whole system, for undoubtedly many results that have been attributed to fine percentages have been due to other causes. It has been found that calculated milk food mixtures which gave good results, when analyzed, did not have the calculated composition; and it is not to be reasonably expected that it could be otherwise, for exact results cannot be obtained unless each specimen of the milk is chemically analyzed, which is out of the question as some of the analytical

processes are extremely complicated and laborious. In addition, extended experiments on animals, where perfect control was obtained, have shown that mathematical accuracy in composition of feeding mixtures cannot be made the basis of successful feeding. In considering cereal gruels in this table the only divisions made are proteids and carbohydrates. Cereals contain only small quantities of fat and mineral matter, and when made up into gruels the quantity of these elements actually present is so small as not to warrant their separate consideration on a percentage basis.

APPROXIMATE PERCENTAGE COMPOSITION OF GRUELS.*

	PEARL BARLEY.		BARLEY FLOUR.		WHEAT FLOUR.		ROLLED OATS.	
	Proteids.	Carbo-hydrates.	Proteids.	Carbo-hydrates.	Proteids.	Carbo-hydrates.	Proteids.	Carbo-hydrates.
1 ounce to quart...	0.14	1.34	0.195	2.093	0.331	2.161	0.262	1.669
2 ounces to quart..	.28	2.68	.390	4.186	.662	4.322	.524	3.338
3 " " " ..	....	....	.585	6.279	.993	6.483	.786	5.007
4 " " " ..	....	....	.780	8.372	1.324	8.644	1.048	6.676
5 " " " ..	....	....	.975	10.465	1.655	10.805	1.310	8.345
6 " " " ..	....	....	1.170	10.558	1.986	12.966	1.572	10.014
7 " " " ..	....	....	1.365	14.651	2.317	15.127	1.834	11.683
8 " " " ..	....	....	1.560	16.744	2.648	17.288	2.096	13.352

Plain gruels cannot be made much stronger than two ounces to the quart. *Dextrinized* gruels may be made up to as high as eight ounces to the quart.

The high proteid gruels are of great value in many diverse conditions. The author has employed them in per-

* Since this work was done a series of flours for making gruels, known as "Cereo-gruel Flours," has been put on the market. The cover of the package is used for measuring the flour, and on the label is given the composition of the gruels of different strengths. Great accuracy is thus possible in making gruels of any kind or strength from directions printed on the labels.

sistent vomiting in patients of all ages; in the enfeebled digestive states accompanying typhoid and other fevers, and in general exhaustive conditions where the digestive and assimilative functions are at their lowest ebb.

There is a widespread erroneous belief that vegetable proteids are not good tissue builders and are not readily digested. A moment's thought will show that they must be nutritious, for the greater part of the animal tissues of the entire earth are built up from vegetable proteids. All of the lean meat of beef, mutton, and pork is derived from vegetable proteids. The proteid of bread is vegetable, and it is almost entirely digested. Recent studies on the digestibility of bread, conducted under the supervision of Atwater,* in which correction for metabolic products in the fæces was made, show that as high as ninety-eight per cent of the proteid of white bread is digested by men.

Rockwood † has shown that the proteid of oatmeal is as thoroughly digested as meat, if it has been separated from the fibre. The reason cereal proteids are apparently indigestible is that they are enclosed in cellulose which prevents the action of the digestive fluids; or the food is so coarse that it is hurried through the digestive tract and thus escapes the action of the digestive juices. Digestive experiments *in vitro* show the proteid of cereals to be easily digested if sufficient time is allowed. Cereals in the form of well-cooked gruels have the cellulose rup-

* "Studies on the Digestibility and Nutritive Value of Bread at the Maine Agricultural Experiment Station," 1899–1903. C. D. Woods and L. H. Merrill.

† "The Utilization of Vegetable Proteids by the Animal Organism." E. W. Rockwood. Am. Jour. Physiol., 1904. No. 4.

tured, and so expose the proteids that they may be easily acted upon by the digestive enzymes. Edsall and Miller* have recently done some exhaustive work on the digestibility and metabolism of vegetable proteid in infants, and found that very often this form of proteid was utilized to better advantage than the proteid of milk.

*"The Dietetic Use of Predigested Legume Flour, Particularly in Atrophic Infants: with a Study of Absorption and Metabdlism." By David L. Edsall, M.D., and Caspar W. Miller, M.D. Am. Jour. Med. Sciences, April, 1905.